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ABSTRACT

This three-volume set of student texts is intended for use in an extension course to prepare Air Force graphics specialists. The first volume deals with basic equipment, materials, lettering, and drafting (including geometric and graphic construction). Addressed in the second volume are composition and layout techniques and the fundamentals of drawing the human form, cartoons and caricatures, and landscapes and seascapes. The third volume, which deals with visual communications, covers projectual design, printed materials, and special techniques. Each volume includes instructional text, exercises, answers to the exercises, and a bibliography. Volume review exercises and a change supplement for the package are also included. (MN)

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GRAPHICS SPECIALIST

(AFSC 23151)

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CDC 23151

GRAPHICS SPECIALIST

(AFSC 23151)

Volume 1

Basic Equipment, Materials, Tools,
Lettering, and Drafting

Extension Course Institute
Air University

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Preface

YOU MUST obtain certain information and develop certain skills to become a graphics specialist. You can obtain this information by studying this Career Development Course (CDC), which covers fundamentals, principles, theory, and concepts associated with the graphics specialty. This CDC is composed of three volumes and supplements designed to bring you to a 5 skill level. A CDC cannot provide the necessary drawing practice that is required to reach any skill level, so your trainer will have to see that you get that practice.

The behavioral objectives contained herein are designed to help you understand what the subjects are all about. Studying the text and achieving the objectives will give you the fundamental knowledge needed to perform as a graphics specialist. Be guided by the behavioral objectives, and answer all the exercises for each chapter. Then refer to the answer section in the back of the volume to check your answers.

This first volume of CDC 23151 was written to extend your familiarization with the basic principles of the graphics career field. Volume 1 consists of four chapters that cover the care and use of equipment, basic materials, the fundamentals of lettering, and geometric and graphic construction.

Foldouts 1 and 2 are printed and bound in the back of the volume.

Code numbers appearing on figures are for preparing agency identification only.

The inclusion of names of any specific commercial product, commodity, or service in this publication is for information purposes only and does not imply indorsement by the Air Force.

To get an *immediate response* to your questions concerning subject matter in this course, call the author at AV 926-2795 between 0700 and 1500 MT, Monday through Friday. Otherwise, write the author at SCHS/TTMZC, Lowry AFB, CO 80230 to point out technical errors you find in the text, volume review exercise, or course examination. Sending subject matter questions to ECI slows response time.

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This volume is valued at 24 hours (8 points).

Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the Index of ECI Study Reference Material to determine the correct references to study.

Acknowledgement

FIGURES 2-32 and 3-26 of Volume 1 have been reproduced by permission of M. Grumbacher, Inc., 460 West 34th St., New York, New York 10001. Our special thanks are extended to Mr. Gordon W. Matlock for his gracious cooperation.

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NOTE: This course teaches through numbered lesson segments, each containing a behavioral objective, text, and exercises. The objective sets your learning goal. The text gives you the information you need to reach that goal, and the exercises let you check your achievement. When you complete each segment, see whether your answers match those in the back of the volume. If your response to an exercise is incorrect, review the objective and its text.

CHAPTER 1

Care and Use of Equipment

MANY OF THE problems of today are caused by a lack of communication. Word languages are highly sophiscated systems of communication, but they are still inadequate in many instances, especially when describing physical things. Drawing is a graphic language that communicates in the universal tongue of art. It is a language that expresses and conveys ideas of shape, size, and construction. As with any form of communication, the tools of the trade are your most important assets. The use and care of this equipment is vital to the graphics specialist, for it is his or her voice in the universal language of art.

1-1. Care of Equipment

Equipment care is the first order of business with any graphics specialist. Equipment well cared for denotes a person who does or has the potential of doing exceptional work. Few workers can do a good job with poor or badly misused equipment, and the graphics specialist is no exception. Giving a poor craftsman the best equipment in the world will not appreciably improve his or her work. A good craftsman, however, will usually produce better work if the equipment is well cared for.

001. Cite the rules for proper equipment care.

Rules to Observe. These rules are:

(1) Have a place for each piece of equipment and keep it there when not in use.

(2) Keep all instruments CLEAN.

(3) Never expose any pointed equipment to the possibility of point damage.

(4) Never use any instrument for any purpose except th for which it was designed.

(5) Electrical equipment should be unplugged when n in use.

Each instrument and piece of equipment was designed to do a particular job. Learn what that job is and use your tools accordingly. Most good equipment can be kept clean with mere soap and water, although some equipment may require special solvents for cleaning.

Before you begin to draw, arrange your equipment in an orderly manner. Place each article so that you can reach it easily, but so that you will not hit it when you use the T-square or drafting machine and triangle. Keep your tools in their proper places when you are not using them; good tools are expensive and easily damaged. A systematic arrangement is timesaving and efficient and decreases the likelihood of your accidentally dropping or pushing something off the table.

Exercises (001):

1. List two of the five rules for equipment care.

2. Why should you arrange your equipment before and during drawing?

1-2. Use of Equipment

Most graphic shops in the Air Force will be furnished with standard drafting furniture and equipment. Subsequent material describes this equipment and also presents suggested methods for obtaining maximum utilization.

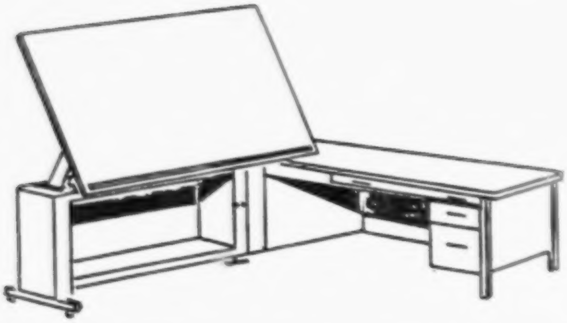
002. Specify the purpose of equipment to be used in a graphics specialist's work area.

Drawing Tables and Boards. Drawing tables and boards come in various sizes and styles as outlined in figure 1-1. Drawing tables and boards are made of selected soft woods such as white pine, basswood, or some other suitable wood. The board should have a smooth, firm, working surface. Most boards and tables are cleated with a metal edge that prevents warping and also serves as a straight working base for the T-square.

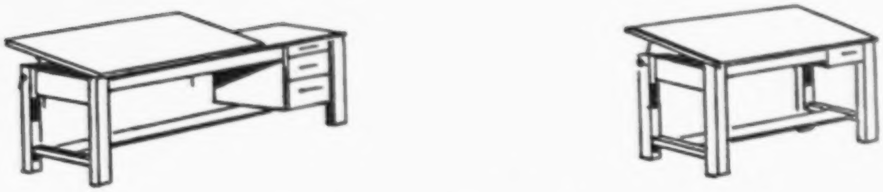
Figure 1-2 is a good example of an inexpensive board with cleated ends. Care should be taken to avoid nicks, chips, and holes of any kind on the drawing surface. There is a variety of vinyl materials with excellent resiliency for covering any drawing board surface. The cover protects the drawing board surface, reducing glare and providing an excellent drawing surface.

Your drawing table should be adjustable in both height and tilt of the top. Adjust the height of the table so that, if you desire to work in a standing position, you can do so without stooping or holding your arms in a slightly raised position. The table top may be left flat or inclined, according to your preference. Your chair or stool should be high enough so that you can see the whole drawing board, but not so high that you have to lean over uncomfortably to draw. You should be able to look directly at any point of your drawing by slightly shifting your body. That is, your line of sight should be approximately perpendicular to the drawing surface.

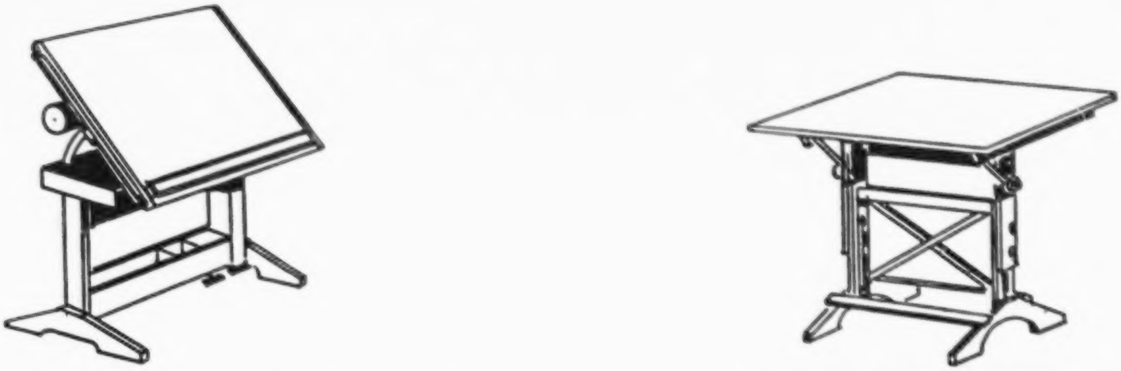
Lamps. Since you will be using your eyes constantly, it is important that your working area be well lighted. Natural light is best, if available and ample, although in the



L-SHAPED DRAFTING TABLE AND REFERENCE DESK. THE DRAWING BOARD IS ADJUSTABLE TO ANY ANGLE.



DRAFTING TABLES WITH ADJUSTABLE DRAWING BOARDS THAT MAY BE TILTED UP TO A MAXIMUM OF 45°. TABLE SHOWN ON THE LEFT ALSO HAS A FLAT SURFACE FOR TOOLS OR REFERENCE MATERIAL.



FRENCH TABLE; ADJUSTABLE TO ANY ANGLE FROM HORIZONTAL TO VERTICAL.

PEDESTAL DRAFTING TABLE; SPACE SAVER AND ADJUSTABLE.

Figure 1–1. Drawing tables and boards.

majority of cases, acceptable natural light will be the exception rather than the rule. Most offices are insufficiently lighted with fluorescent overhead fixtures. Generally, these fixtures are inadequate in regards to quality and intensity of light. Adjustable lamps serve to improve the lighting conditions. The most popular type of adjustable lamp is the floating-arm type of fluorescent fixture that clamps onto the desk or drafting table. Arrange your lighting to come from the front left, if your are right-handed; or from the front right, if you are left-handed. This eliminates shadows cast by drawing instruments and your hands. Finally, avoid glaring lights and reflections, as they contribute to eye-strain.

Light Tables. Light tables are used for viewing opaque, translucent, or transparent material. The graphics specialist will find the light table a very useful tool when tracing prints, opaquing negatives, and making color separations. A light table may be used as a drawing table, but this

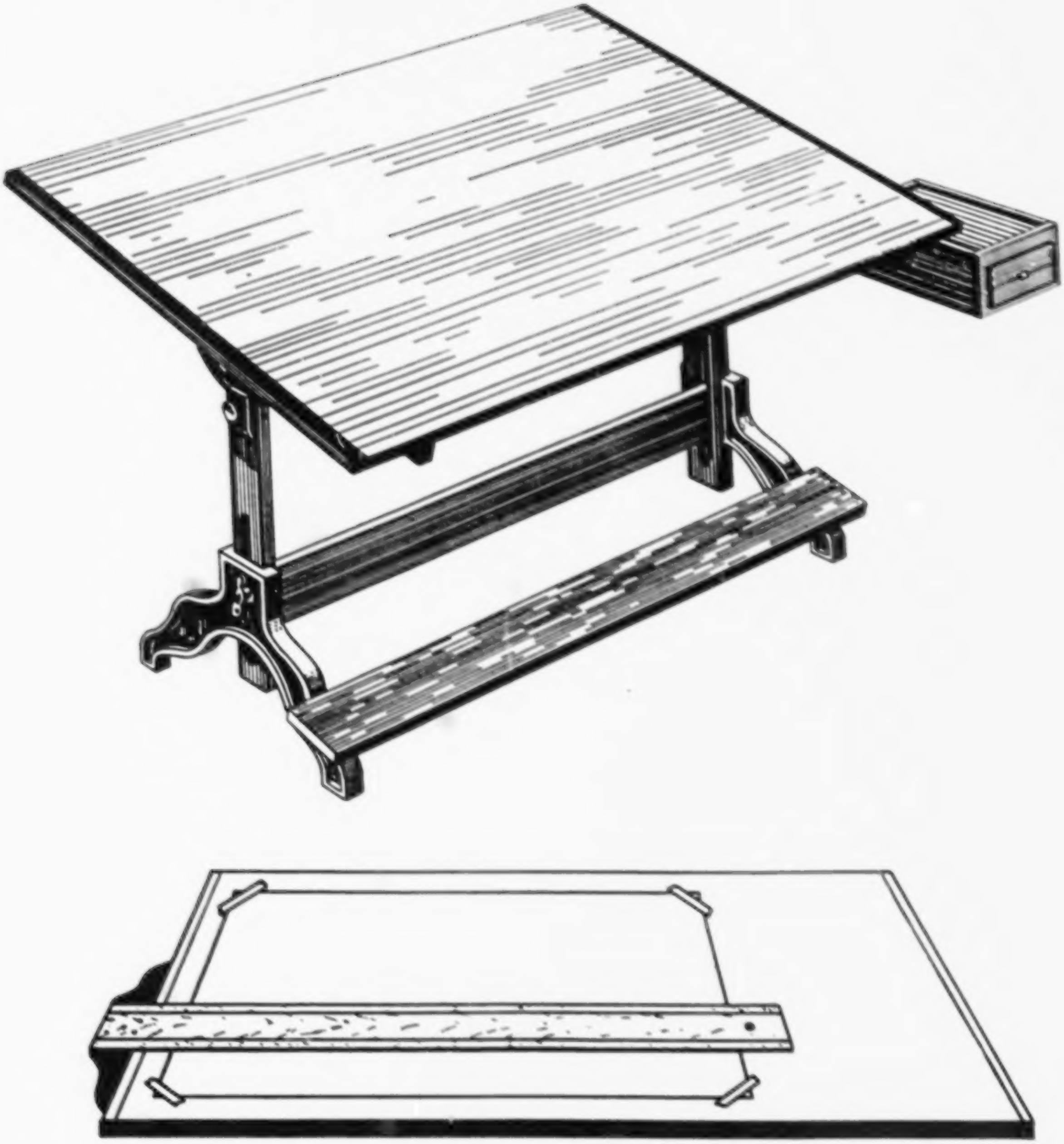


Figure 1-2. Drawing board and cleated ends.

practice is not recommended except in an emergency. Precautions to be observed when working on a light table, because the top is made of glass, are to avoid excessive pressure on the glass surface and to avoid scoring the surface with sharp tools. In either case, a break could cause serious injury.

The light table has a series of fluorescent light tubes located in the front or on the recessed floor of the glassed-in section. The white reflectors spread the light source within the table, and the glass working surface is frosted underneath to diffuse the light. Figure 1-3 illustrates a typical light table.

Work Tables. Work tables are used mainly for jobs that would otherwise damage the surface of a drawing board. These work tables are used for such operations as mounting drawings, maps, photos, or cutting paper, matts, or illustrated board.

The top of the work table should be large enough to accommodate the largest sheet of illustration board without any overhanging edges. Cover the table with one or more scrap sheets of illustration board, held firmly in place with tape. This supplemental covering will prevent the cutting blade from slipping on the smooth tabletop. The blade passes through the item you are cutting and partially cuts the illustration board cover. Additionally, if the illustration board cover is not used on tabletops made out of hard material such as formica, the knife, upon cutting through the material, would lose all friction and might slip across the hard surface and cut you or someone near you.

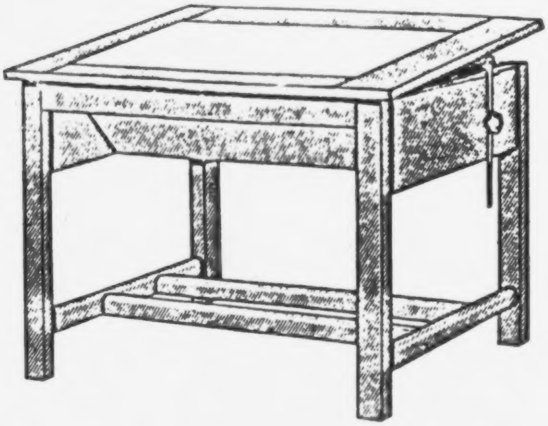


Figure 1-3. Light table.

Tabourets. A tabouret serves as a storage space for frequently used tools and materials. Because most tabourets are on wheels and are portable, you can easily relocate your tools and materials when the need arises. The top of the tabouret is flat with a raised lip around its perimeter. The tabouret will have one or more drawers and a storage space below. These features enable you to keep your most frequently used tools and materials close at hand. Figure 1-4 illustrates a type of tabouret.

Exercises (002):

1. Why is it usually more convenient to use a high stool and a drawing table adjusted to a high level rather than a conventional chair and a drawing table adjusted at a low level?

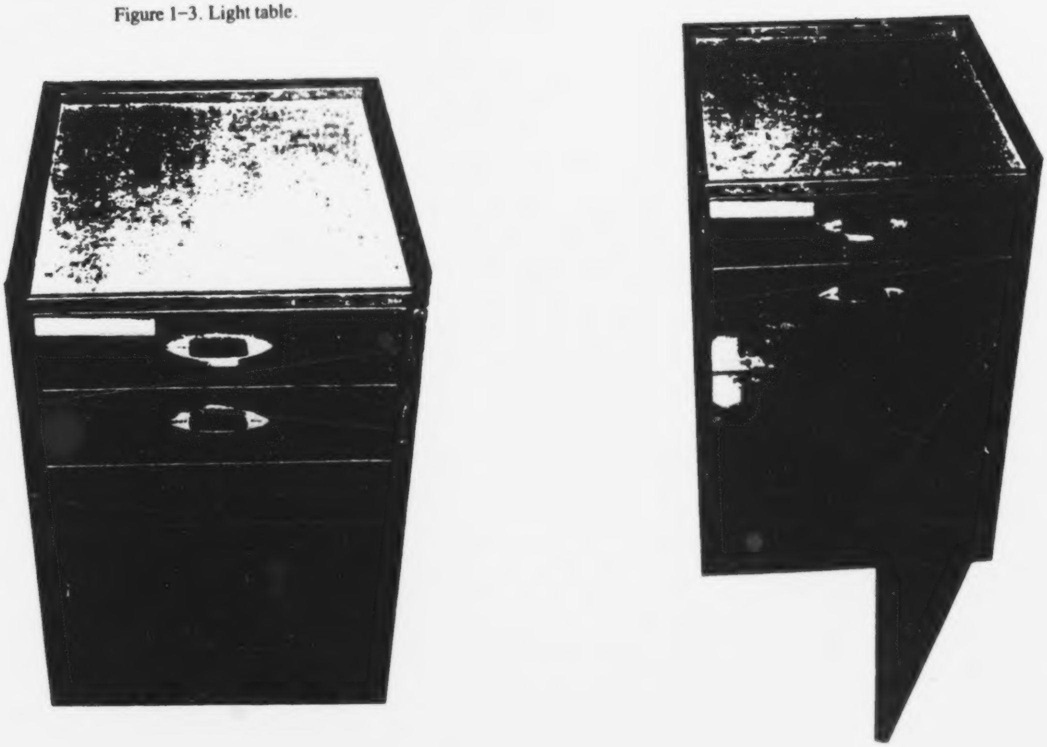


Figure 1-4. Tabouret.

2. If you are right-handed, you should arrange your work area so that the light comes from what direction?

3. Why is the light table a useful tool?

4. In what situation should a work table be used instead of a drawing table?

5. What is the purpose of a tabouret?

CHAPTER 2

Materials and Tools

THE JOBS YOU will encounter as a graphics specialist will vary tremendously. You may be expected to do anything from designing a command presentation to painting a mural. No matter what your specific job may be, there are materials and tools that are used in every aspect of your specialty. In this chapter, we will take a look at these materials and tools.

2-1. Materials

The materials used by the graphics specialist in the preparation of artwork include such items as paper, board, pencils, ink, and other such items.

003. Specify the features and dimensions of drawing paper and drawing boards.

Drawing Paper. Drawing paper is one of the key ingredients for most illustrations. It is the surface upon which most drawings are made initially. Drawing paper is made in a variety of qualities for various purposes. It may be hot-pressed or cold-pressed (this determines the surface finish), and it can be purchased in both rolls and sheets. Most drawing paper is chemically treated so that the colors will remain true even if constantly exposed to harsh light.

In general, paper should have sufficient grain to take pencil or ink, and a hard surface so that the pencil will not groove it or that ink will not bleed. Drawing paper must also have good erasing qualities so that, when an erasure does occur, the surface of the paper will remain smooth and hard enough to be redrawn upon.

Other drawing papers and drawing boards can be identified by their trade names, but they all serve the same purpose. The ultimate purpose of any drawing surface is to supply the artist with a vehicle on which he or she can express ideas in any media or technique that is available. In many cases, drawing boards are manufactured for specific media or technique.

Paper sizes. The Air Force maintains a standard system for paper sizes. It is based on the 8½" x 11" dimension. The paper sizes are designated by letters as follows: A = 8½" x 11"; B = 11" x 17"; C = 17" x 22"; D = 22" x 34"; E = 34" x 44". As you can see, when these sheets are folded in half along their longest sides, they will fold down to fit into standard Air Force letter files.

Paper features. There are many types of papers and paper products designed to fit any specific need you may run into. Paper, which is usually designated as a single ply, is given a certain weight characteristic. The weight of the paper is figured by the pound weight of a ream (500 sheets) of 17" x 22" paper. That means that, if the paper that you are using is rated at 120 pounds, 500 sheets of that paper in the 17" x 22" size weighs 120 pounds. Therefore, the higher the weight rating, the thicker the paper.

Cardstock and boardstock are usually multi-ply papers. They are classified by surface finish. Hot-pressed board has a hard slick surface, which does not absorb ink or paint quickly. This allows you to draw a crisp, clean line. Hot-pressed board is an ideal surface for preparing graphics that require a high degree of accuracy.

Cold-pressed paper, on the other hand, has a textured surface. This texture is called *grain* or *tooth*. The tooth of the board creates very minute peaks and valleys on the surface of the paper. The variances in surface heights allow graphite or pigment particles to adhere to the paper surface in varying concentrations. Naturally, the pigment or graphic concentrations will be heavier on the peaks and lighter or nonexistent in the valleys. Therefore, cold-pressed boards and papers are ideal for graphics that require a tonal effect.

There is a paper made specifically for any job. As you gain experience, you will be able to narrow your selection to a few paper and board types that will adequately handle the majority of your needs.

Tracing Paper. Tracing paper is just what the name implies—it is a natural (translucent) or transparent paper used to trace all or parts of drawings and blueprints when reproduction is not possible from the original. Otherwise, it should have all the qualities of good drawing paper. Tracing paper varies widely in color, thickness, and surface qualities. Therefore, the grade of pencil or ink techniques must be adjusted to suit the paper. All paper has a front and a back. Most of the time the two sides are the same, but with drawing paper you have to be careful. Drawing paper may have a smooth and a textured side, or a white and an off-white side; the front side is usually white or smooth.

Exercises (003):

1. Upon what dimension does the Air Force base its paper sizes? Why?

2. What are the qualities of good tracing paper?

3. How is the weight of paper determined?

4. What is the difference between hot-pressed board and cold-pressed board?

004. Specify the characteristics of the two basic mediums.

Basic Mediums. As a graphics specialist, you will often use the basic mediums to prepare artwork. This section contains information relating to the characteristics of the two basic mediums, pencil and ink. Other mediums will be covered in Volume 2 of this CDC.

Pencil. The pencil is the most valuable tool you will ever use as a graphic specialist. Regardless of what medium your drawings will be done in, you will do the planning with a pencil. The pencil is the most versatile of all drawing tools; you can create a range of values from the subtlest gray to the richest black and create the thickest and thinnest lines. In addition, when you want to make a change to the preliminary drawing, the pencil lines can be erased.

The selection of a grade of pencil lead is to some extent a matter of personal preference. Special pencils are used for drawing, as illustrated in figure 2-1. There are 18 grades of pencil leads, 17 of which are shown in figure 2-1. Leads are divided into three general categories: hard, medium, and soft. The breakdown is as follows:

9H to 4H	hard
3H, 2H, H, F, HB, and B	medium
2B to 6B	soft

Pencils in the 2B to 6B category are classified as soft. The composition of the graphite is such that it produces a very dense, shiny black line. Because the graphite is so soft, you should be very careful when you work with these pencils. The lines produced by these pencils are easily smudged. Protect your work by laying a sheet of paper over your completed work area. This will keep your hand from resting on your completed work and smearing it.

You can use these same smudging properties to your advantage. Because the graphite is so soft, it can be blended easily to produce some very striking tonal effects.

The medium density pencils (B and 3H) are general-purpose pencils. The graphite in these pencils is harder and produces a line that is finer and lighter than the softer pencils. These pencils are ideally suited for sketching, writing, tracing, basic lettering, and general layout work.

The third category of pencils are classified as hard. These pencils are designated 4H through 9H. These pencils maintain a sharp point and produce a sharp line of light density. They are extremely valuable when a high degree of accuracy is desired for charts and graphs for the preliminary layout work for drafting.

More important than the quality of the pencil is the condition of the point. The proper shape for a pencil point is shown in figure 2-2. The tapered wood portion should range from 7/8 inch to 1½ inches long, and 3/8 inch of lead should be exposed, as shown in part A. This can be done with a sharp knife or razor blade, or by a special pencil sharpener which cuts away only the wood, leaving the point as shown in part B. After using either of these methods, you should bring the lead to a point by means of a file or sandpaper. Three different points are commmonly used. For a conical point, as shown in part C, rotate the pencil slowly while you rub it back and forth on the file or sandpaper (fig. 2-3). The pencil should be inclined to the direction of motion. To produce the wedge point, shown at E in figure 2-2, the opposite sides are rubbed down. Some artists prefer the screwdriver wedge point shown at D. This point requires the screwdriver wedge point shown at D. This point requires additional sanding at the corners of the wedge. The elliptical or bevel point, item F, is made by sanding the lead entirely on one side.

Each type of point is useful and has certain advantages. The wedge point is used for drawing straight lines, since it does not wear down so rapidly. Its use, however, is limited to drawing straight lines. The conical point is used for general-purpose work and for lettering where a thin uniform line is required. The bevel or elliptical point is recommended for use in the compass, as it has the same advantages there as the wedge point has for drawing straight lines. The soft lead pencils with beveled points are often used for shading. Since drawing pencils wear away rapidly, you should always keep a sandpaper pad handy to resharpen the lead.

The disadvantage of using an ordinary drawing pencil is that you must take time to sharpen it, and as it becomes shorter, it is more difficult to handle. Semiautomatic or mechanical pencils, shown in figure 2-4, do not have these disadvantages. Equipped with a chuck to clamp and hold

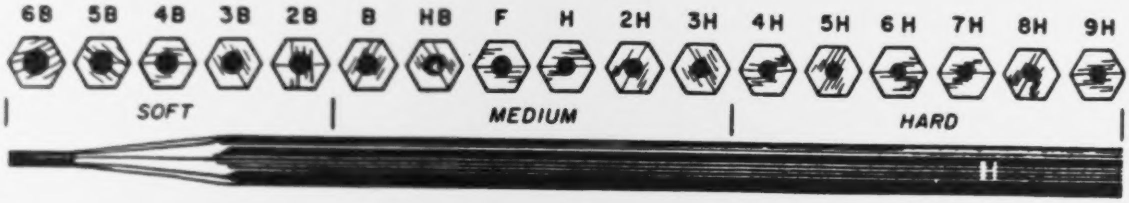


Figure 2-1. Grades of drawing pencils.

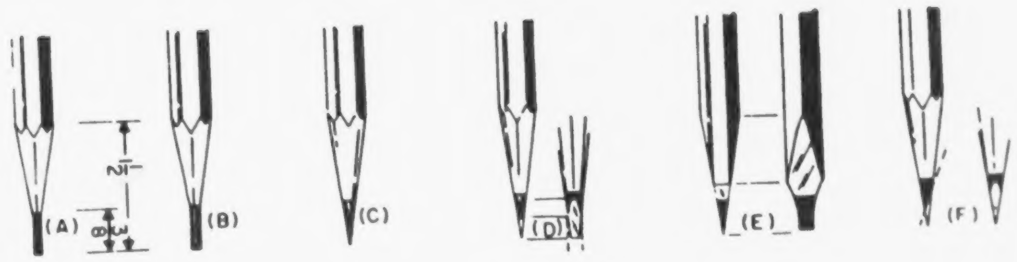


Figure 2-2. Various pencil point shapes.

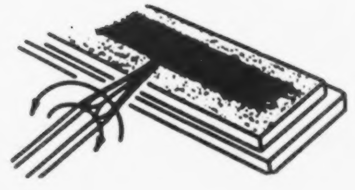


Figure 2-3. Sanding pad.

the lead, they can be quickly adjusted, the point sanded as the lead of a wooden pencil, and they maintain their length. In addition, the entire lead can be used.

Ink. Common black drawing ink is made of finely ground carbon suspended in a mixture of water and gum arabic. The gum arabic acts as a binder and makes the ink cohesive, opaque, and waterproof. Waterproof ink is very durable and is preferred. Nonwaterproof ink is easier to work with, but slower to dry and very easy to smudge.

Ink dries quickly, so keep the bottle tightly closed except when filling the pen or drawing instrument. This will help eliminate evaporation and keep the ink workable. If the ink gets too thick, it can be thinned by adding a few drops of water until the ink reaches a workable consistency.

The majority of your work will require black ink only; however, ink is made in almost any color for any purpose. If your work is going to be reproduced photographically, use black, dark blue, or red ink. These three colors will insure the best possible black and white copy. Other colors may produce a copy, but the quality will be lessened.

Exercises (004):

1. What are the three general categories of lead for a drawing pencil?

2. What are the three different pencil-point types?

3. What substances are used to make drawing ink?

4. Which colors of ink reproduce best photographically?

2-2. Tools

This section covers the nomenclature, use, care, and maintenance of some of the more common items you as an graphics specialist will be using. Learn the proper use, care, and maintenance of these pieces of equipment and it will make your job much easier.

005. Compare the features of the T-square, parallel straightedge, and drafting machine.

T-square. This tool gets its name from its shape, which you probably observed when looking at figures 2-5 and 2-6. It consists of a blade attached at one end to a shorter crosspiece called the *head*. As you can see, the head is mounted under the blade so that it will fit against the edge of the drawing board while the blade rests on the surface of the board.

The T-square is used for drawing horizontal lines, as shown in figure 2-7. To use the T-square for this purpose, first apply pressure to the head to hold it in contact with the working edge of the board. This keeps the working edge of the blade perpendicular to the working edge of the board. Next, slide the T-square up or down to position its working edge slightly below the point through which you want to draw the line. Then, hold the head of the T-square against the edge of the board as you move the pencils along the working edge of the T-square. Draw the line with the pencil tilted in the direction of movement at an angle of approximately 60 degrees from the surface of the paper. Rotate the pencil between your fingers as you draw the line so that the lead wears evenly and produces a line having the same thickness throughout its length.

Of course, T-squares are no good if the lines are not straight or parallel to each other. Let's look at two of the most common problem areas.

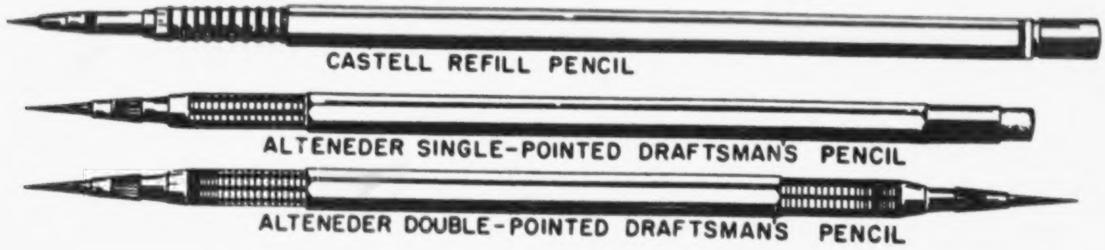

CASTELL REFILL PENCIL
ALTENEDER SINGLE-POINTED DRAFTSMAN'S PENCIL
ALTENEDER DOUBLE-POINTED DRAFTSMAN'S PENCIL

Figure 2–4. Mechanical pencils.

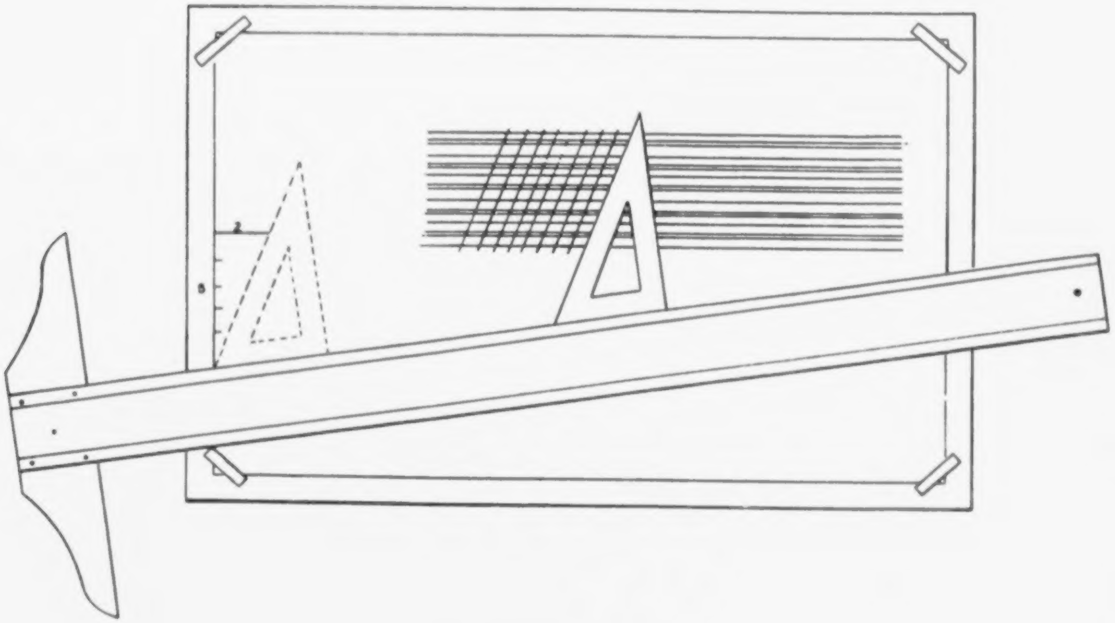


Figure 2–5. T-square.

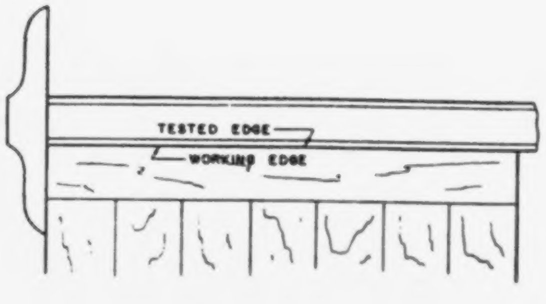

TESTED EDGE
WORKING EDGE

Figure 2–6. Checking working edge of drawing board.

A T-square with a loose or "rocking" head is the only problem that you should ever try to correct. You will never be able to draw parallel lines when the head of your T-square doesn't hold the blade in a permanent perpendicular position. If the head of your T-square is loose, remove the screws that hold the blade and head together. Place a small amount of white glue in and around the screw holes, and align the blade at a 90-degree angle to the head, then reattach the blade to the head. The T-square should be as good as new, and you can use it as soon as the glue has had a chance to set properly.

A more serious problem is a T-square with an uneven working edge. To test the working edge of the blade,

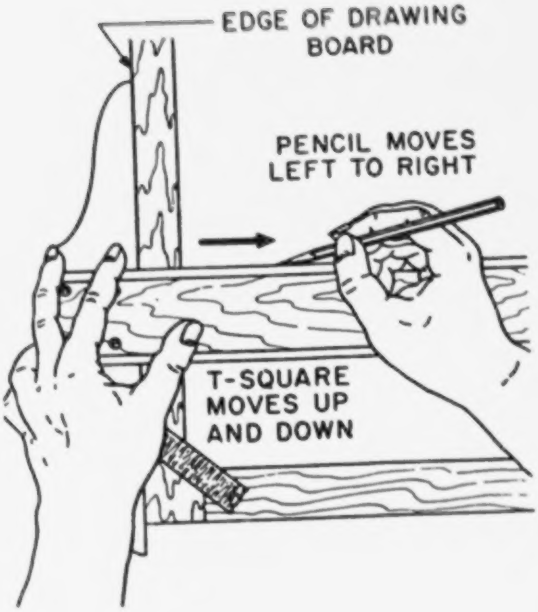

EDGE OF DRAWING BOARD
PENCIL MOVES LEFT TO RIGHT
T-SQUARE MOVES UP AND DOWN

Figure 2-7. Drawing a horizontal line.

carefully draw a sharp line with a pencil along the entire length of the blade. Turn the T-square over and draw a line along the same edge. If the working edge is straight, the two lines will appear as one. If there is a space between the lines, the working edge of the blade is not straight and the T-square should be discarded.

The best type of T-square maintenance is preventive maintenance. Here are some tips to keep your T-square in good shape:

- Never use the blade as a guide for a knife when cutting paper or boardstock.
- To keep your T-square true, always store it hanging by the hole in the end of the blade, or lay it on a flat surface.
- DO NOT DROP YOUR T-SQUARE!!!
- Never use the lower edge of the blade.

Parallel Straightedge. Many graphics specialists prefer a parallel straightedge to a T-square. The parallel straightedge is permanently attached to the drawing board by a system of cords and pulleys so arranged as to give exact parallel motion to the straightedge as it is moved vertically up and down the board.

The parallel straightedge has two fundamental advantages over the T-square. Supported at both ends, it maintains parallel motion automatically, and it may be moved up or down the board with pressure at any point along its length. These advantages become particularly significant when you are working on large drawings.

As with the T-square, always draw lines along the upper edge of the parallel straightedge. A word of caution: As with T-square, do not use the plastic edge as a cutting guide.

Drafting Machines. The drafting machine—or parallel motion protractor, as it is sometimes called—is one of the most useful and timesaving devices that you will use. You can use it in place of a T-square, triangle, scale, and protractor. There are two types of drafting machines—the arm-and-band type shown in figure 2-8 and the tracked type shown in figure 2-9. Essentially both machines are the same. The tracked type has the advantage of being more versatile, accurate, trouble free, and can accommodate larger drawings. The arm-and-band type, however, is more common and less expensive.

As you can see in figure 2-8, the drafting machine is attached to the top edge of the drawing table with the straightedges resting on the surface of the drawing table or paper. The controlling head of the machine provides a means of adjusting and locking the straightedges at any desired angle. The supporting links are arranged so that the straightedges always remain at the desired angle no matter where they are moved on the board. Thus, when the long blade is set to a horizontal position, it will remain horizontal regardless of the position of the control head on the drawing table. Interchangeable straightedges marked with standard scale divisions permit you to use the drawing machine for many types of drawing.

Since the various parts of the drafting machine are metal, the accurate relationship of one part to another is not subject to change. However, they do have certain inherent faults. Unless the metal straightedges are pressed firmly against the drawing by placing one hand at the center of the straightedge, the blade will flex or "swing" slightly when moderate pressure is applied to the free end. The links or bands that control the position of the straightedges must be adjusted properly to eliminate the possibility of introducing error from this source. When using the drafting machine to attain speed, you must take great care not to gain speed at the cost of accuracy.

Exercises (005):

1. What is the primary purpose of a T-square?

2. What advantages does a parallel straightedge have over a T-square?

3. The drafting machine combines the features of what graphic tools?

006. State the functions of triangles and irregular curves.

Triangles. Right-angle triangles are used in conjunction with the T-square or straightedge to draw vertical or inclined lines. The two standard types, as shown in figure 2-10, have acute angles of 45° and 45° and 30° and 60°.

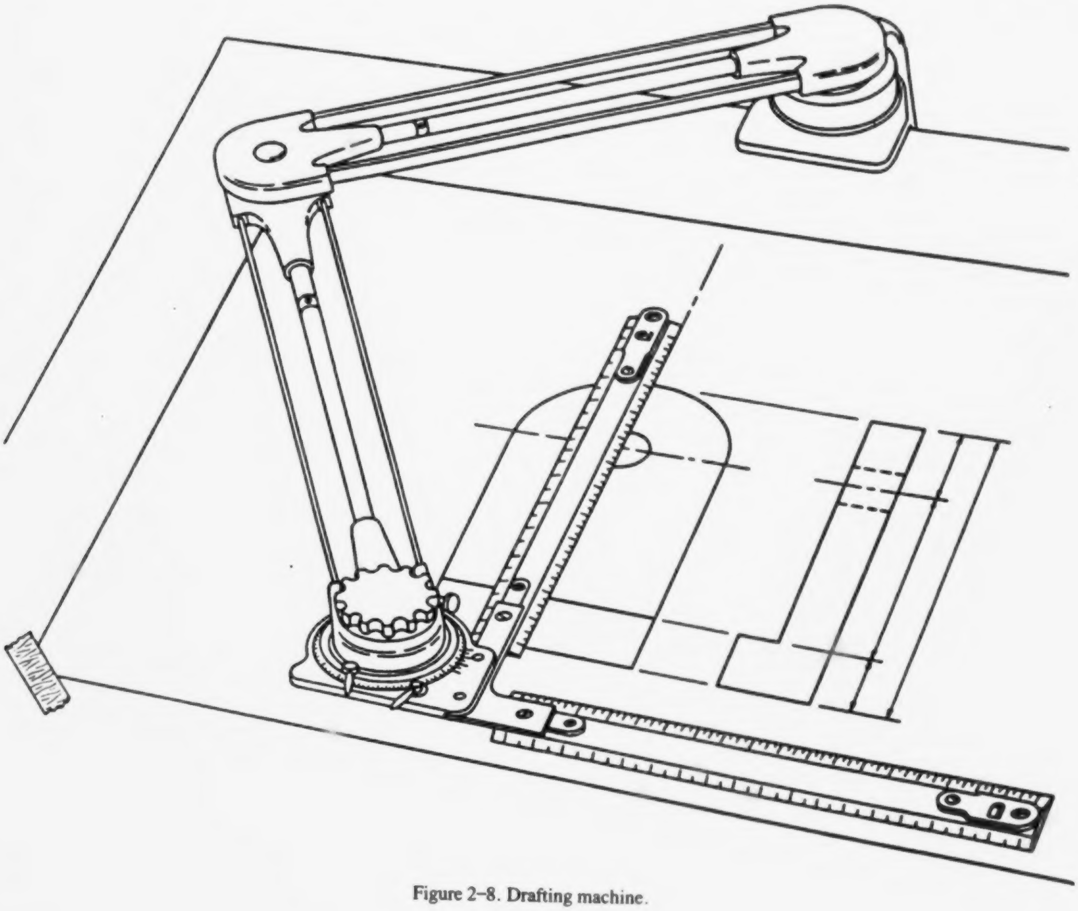


Figure 2–8. Drafting machine.

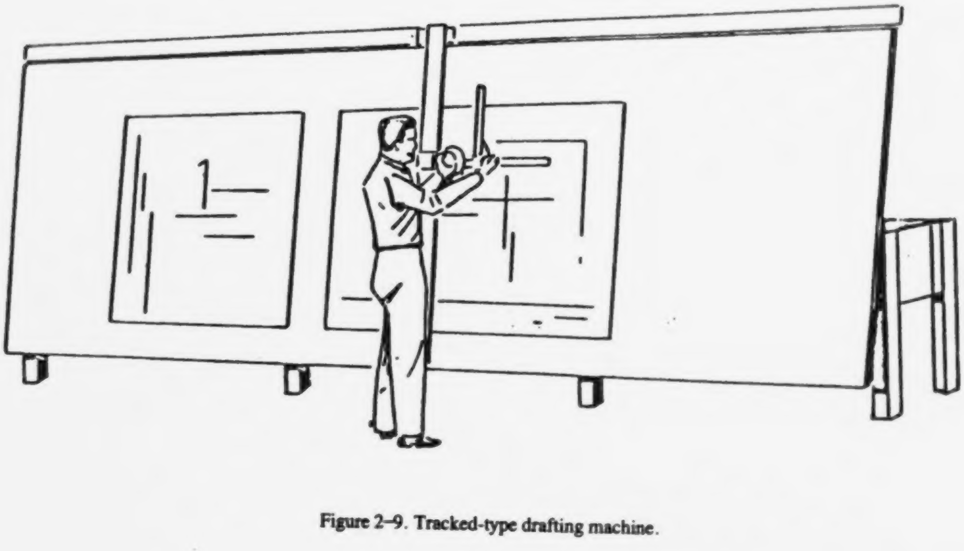


Figure 2–9. Tracked-type drafting machine.

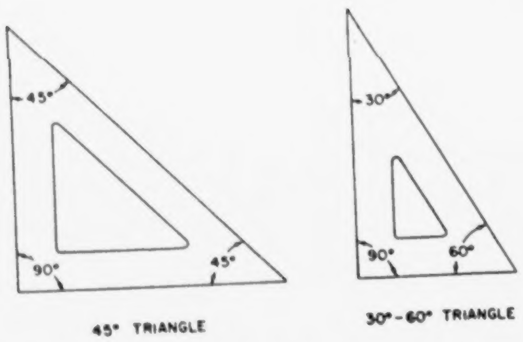


Figure 2-10. Standard triangles.

Triangles are made of transparent plastic so that lines of the drawing may be seen through them. Like a T-square, to be functional, triangles must be accurate. The edges of triangles can be tested for straightness by the same two-point method used to test the working edge of the T-square. Figure 2-11 shows how to check the angles of the triangles.

To check the 90° angle on either triangle, set the triangle against the working edge of a T-square and draw a vertical line through a given point. Then, without moving the T-square, turn the triangle over to position it (see dotted outline in fig. 2-11,A) and draw a second line through the same point using the same edge. If the two lines coincide or are very close together, the triangle is usable.

The 45° angles may be tested by drawing a line at a 45° angle to the horizontal and then checking the opposite angle to see if the edge coincides with the pencil line. This process is shown in figure 2-11,B.

You can test the 60° angle by drawing an equilateral triangle as shown in figure 2-11,C. If the triangle has equal sides, the 60° angle is correct. Of course, if both 90° and 60° angles are correct, the 30° angle will be correct also since the sum of the angles of a triangle is 180°.

The method used to draw vertical lines is shown in figure 2-12. Notice that the left hand not only applies pressure to hold the T-square in position so that the head is against the working edge of the drawing board, but is used also to hold the triangle against the working edge of the T-square. The right hand moves the pencil along the triangle with an upward motion.

You can use triangles singularly, as shown in parts A and B of figure 2-13, to draw lines at angles of 30°, 45°, 60°, and 90° with the horizontal. You also can use them in combination, as shown in part C, to draw lines at angles of 15° and 75° with the horizontal. Part D shows the lines that can be drawn with 30° - 60° and 45° triangles. Since all lines should be drawn from left to right (if you are right-handed), lines sloping downward from left to right will be drawn with a downward motion; those sloping upward from left to right will be drawn with an upward motion. This procedure allows you to see your work better.

When a line must be drawn between two points, a triangle may be used for a straightedge in place of a T-square. As with a T-square, you should be careful not to let the triangle slip when using it as a straightedge. The alignment of the edge of the triangle with the two points may be simplified by using the following procedure:

(a) Place the tip of your pencil on the point which is higher for drawing vertical lines, or on the point which is farther to the right for drawing horizontal and inclined lines.

(b) Move the triangle up against the pencil.

(c) Using the pencil as a fulcrum, pivot the triangle to align its edge with the second point.

Perhaps the most important use of the triangle, T-square combination, is to draw lines parallel or perpendicular to a given line. Figure 2-14 shows the two steps of these procedures. The procedure of drawing parallel lines is shown in part A, and the procedure of drawing perpendicular lines is shown in part B. In each of these procedures, the first step consists of placing the triangle against the T-square and moving them as one until the edge of the triangle is aligned with the given line. Then in the next step, while holding the T-square stationary, you slide the triangle along the working edge of the T-square until the edge of the triangle is aligned with the point through which you wish to draw the parallel or perpendicular line. Naturally, you use the same edge of the triangle to draw parallel lines as you used to align the two instruments in the first step, and you use the edge of the triangle that is perpendicular to that edge when you draw perpendicular lines.

Irregular Curves. These curves are used to draw curved lines which are not segments of circles. They are made of metal or of transparent plastic and come in various shapes, some of which are shown in figure 2-15. The patterns for these curves are laid out in ellipses and spirals or other mathematical curves in various combinations.

Figure 2-16 shows how an irregular curve is used to draw a smooth line through predetermined points. After the points are plotted, a light pencil should be sketched to connect the points with a smooth flowing line. Then apply the curve to it, selecting the part of the curve which most nearly matches a portion of the line. The curve should match the line at a minimum of three consecutive points. When selecting the part of the line to be used, be sure to place the short radius portion of the line to be drawn. In drawing the part of the line matched by the curve, always stop a little short of the distance in which the guide and line seem to coincide. After drawing this portion, shift the curve to find another place that will coincide with the continuation of the line. Avoid abrupt changes in curvature by arranging the curve to coincide for a short distance with the part of the line already drawn. Thus, the lines drawn coincide at each junction and create a smooth curve.

When using the irregular curve as a guide for inking a curved line, hold the ruling pen so that it is tilted slightly in the direction of movement and is in plane perpendicular to the paper. In this position, both blades of the pen will touch the paper at points just off the center of their curved tips. As you move the pen along the edge of the curve, rotate it slowly between your fingers or turn your hand to keep the blades parallel to the edge of the curve.

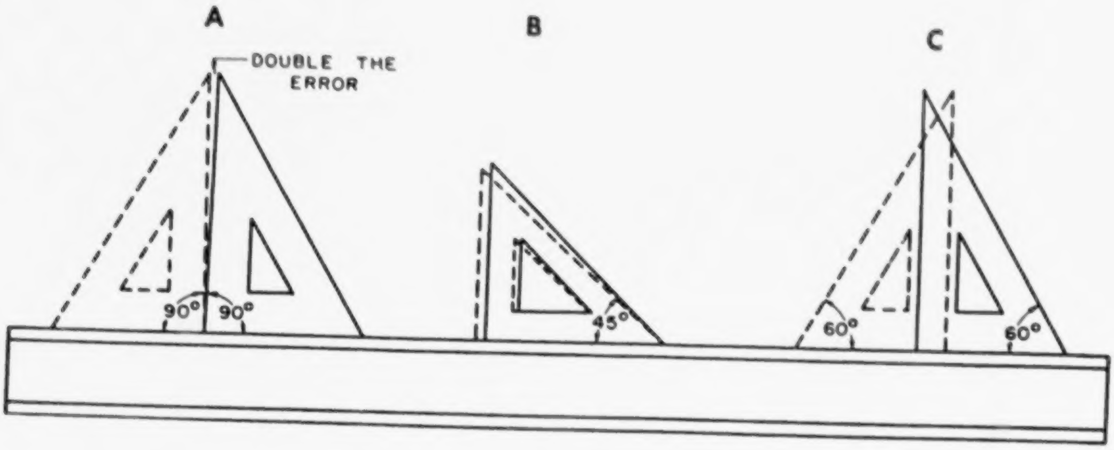


Figure 2-11. Testing triangles.

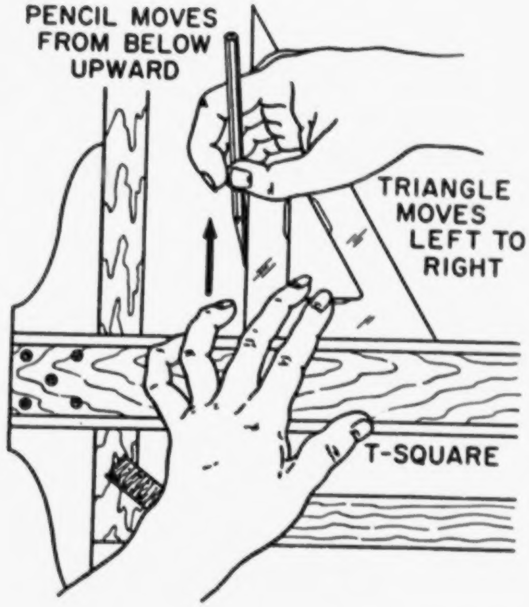

PENCIL MOVES FROM BELOW UPWARD
TRIANGLE MOVES LEFT TO RIGHT
T-SQUARE

Figure 2-12. Drawing a vertical line.

Exercises (006):

1. What are the two types of triangles?

2. What is the primary function of the triangle?

3. What is the purpose of irregular curves?

4. At how many points should the curve match?

007. Specify the purpose of a protractor.

Protractor. A protractor is used for setting off and measuring angles, including those obtained by using the T-square and triangles. Ordinarily, a transparent plastic protractor 6 inches wide is sufficient. Such a protractor is shown in figure 2-17. Notice that the circumference is marked twice with a scale running from 0° through 180° in each direction. Having 0°starting points at opposite ends of the diameter makes the protractor easier to use and read in any position on the drawing board.

To make accurate measurements with a protractor, draw the baseline of the angle so that it extends beyond both zero points of the protractor. The center point of the protractor must be aligned directly over the apex of the angle to be measured or drawn. In laying out an angle, make a light pencil mark on the drawing opposite the appropriate degree mark. Then draw a line from the apex through the pencil "tick" mark to complete the angle.

Exercises (007):

1. What is the purpose of a protractor?

2. How would you measure an angle with a protractor?

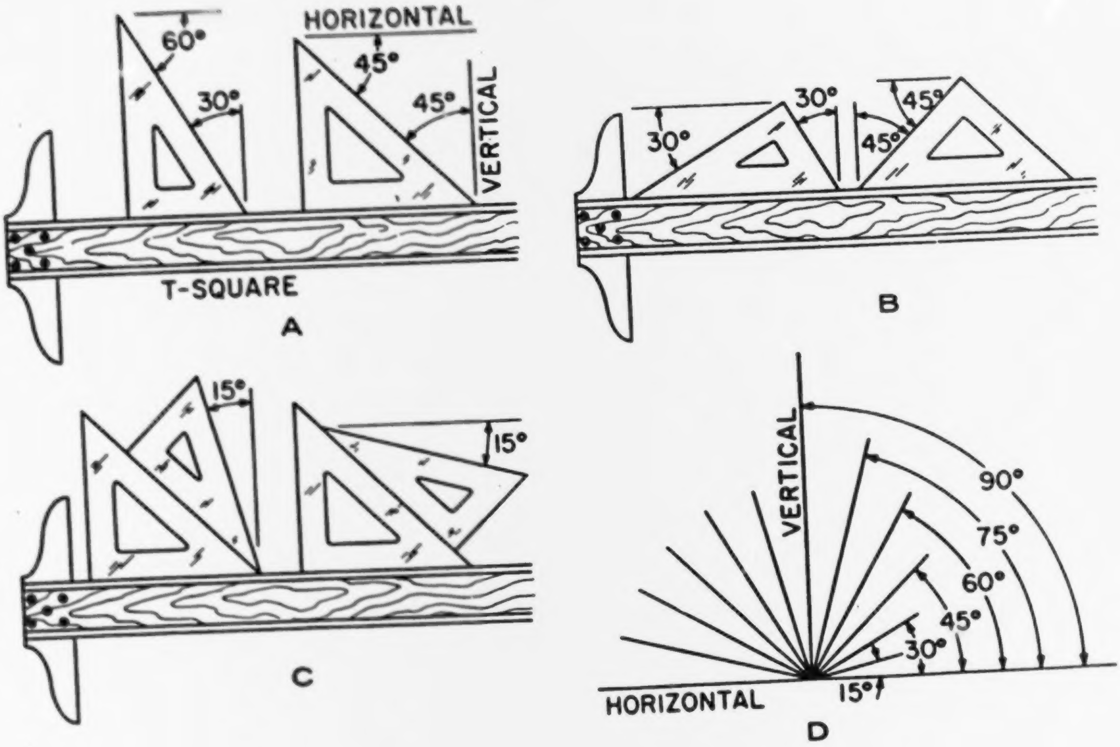

60°
30°
HORIZONTAL
45°
45°
VERTICAL
T-SQUARE
A
30°
30°
45°
45°
B
15°
15°
C
VERTICAL
90°
75°
60°
45°
30°
15°
HORIZONTAL
D

Figure 2-13. Using the triangle.

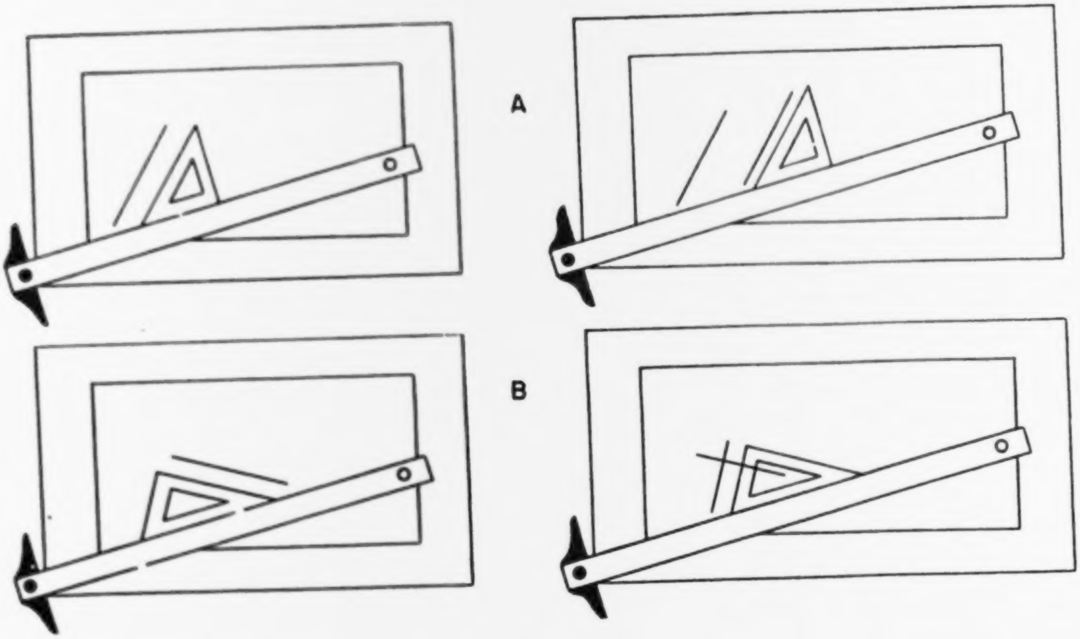


Figure 2-14. Drawing parallel and perpendicular lines.

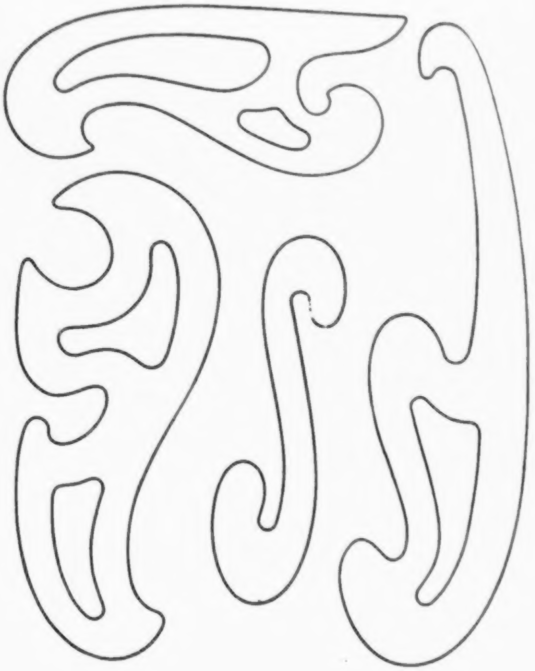


Figure 2-15. Irregular curves.

008. State the types and functions of drafting scales.

Scales. Although you are probably more familiar with the term "ruler," "scale" is the correct term to use for a straightedge that is graduated for measuring purposes. Scales are made with a variety of graduations to meet the requirements of many different kinds of work. For convenience, scales are classified according to their most common uses. Thus we have scales for mechanical engineers, civil engineers, and architects. A graphics specialist will find each of these types of scales convenient for certain types of work.

Mechanical engineering scales are divided and numbered so that fractions of inches represent inches. The most common ranges are 1/8, 1/4, 1/2, and 1 inch to the inch. These scales are known as the size scales because the designated reduction also represents the ratio of size. For example, on the 1/8 scale, 1 inch is represented by each 1/8 of an inch of the scale. These scales are almost always "fully divided"; that is, the smallest divisions run throughout the entire length. They are often graduated with the marked divisions numbered from right to left, as well as from left to right. Mechanical engineering scales are used chiefly for drawing machine parts and small structures where the drawing size is never less than one-eighth the size of the actual object.

Civil engineering scales are divided into decimals with 10, 20, 30, 40, 50, 60, and 80 divisions to the inch. Such scales are usually fully divided and are sometimes

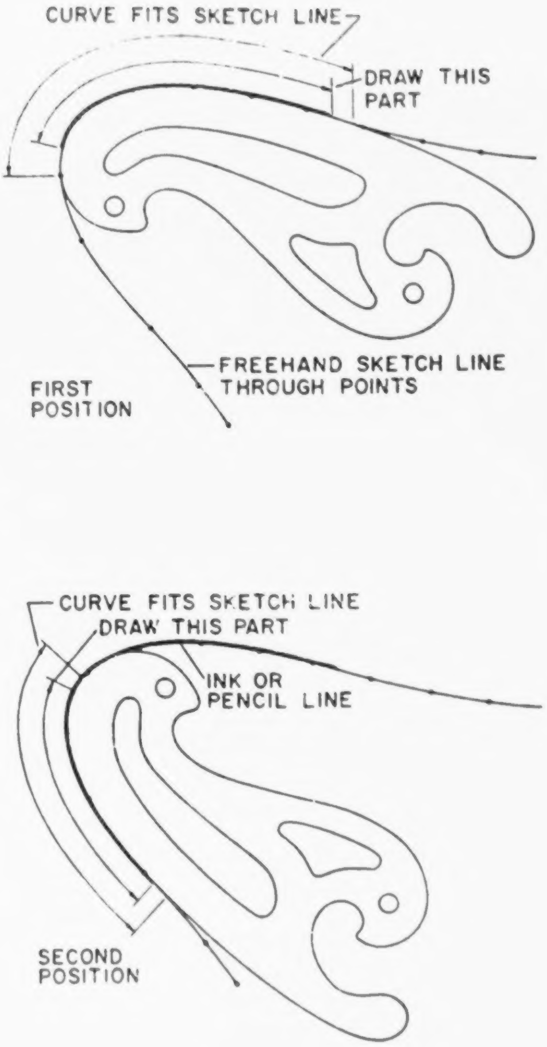

CURVE FITS SKETCH LINE
DRAW THIS PART
FREEHAND SKETCH LINE THROUGH POINTS
FIRST POSITION
CURVE FITS SKETCH LINE
DRAW THIS PART
INK OR PENCIL LINE
SECOND POSITION

Figure 2-16. using an irregular curve.

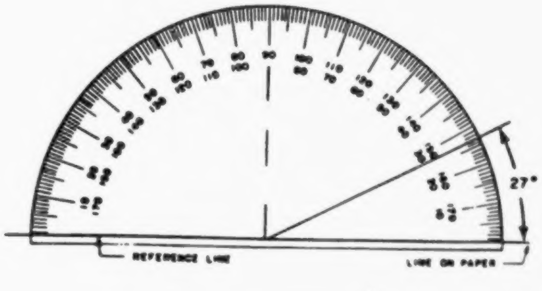

27°
REFERENCE LINE
LINE ON PAPER

Figure 2-17. Using a protractor.

numbered both from left to right and from right to left. They are used chiefly for plotting and drawing maps, although they are convenient for any work where divisions of the inch in tenths is required.

An architect's scales are divided into proportional divisions representing feet and inches, and are used to make scaled-down drawings. These scales have unit divisions of 3/32, 1/8, 3/16, 1/4, 3/8, 1/2, 3/4, 1, 1½, and 3 inches. Each unit represents 1 foot. They are usually "open divided," that is, the units representing feet are shown along the entire length, but only the end units are subdivided into fractions representing inches. Three samples are shown in figure 2-18.

We are all familiar with the top scale (12-inch ruler). We were introduced to it during our early school days. It is divided into 12 inches, and these units are further divided into 16 equal parts. If you use this scale to make a scaled-down drawing of an object, you must calculate the lengths that you require. In some cases, this may be difficult. If you were using the scale, 1 inch equals 1 foot, you would have little or no trouble finding the measurement representing 5 feet 3 inches, because 3 inches equals 1/4 foot and is represented by 1/4 of a inch on the scale. You merely mark off 5¼ inches for your measurement. However, suppose that you wanted to find the scale measurement of 5 feet 4 inches. This is not so easy. When you convert 4 inches into feet, you get 1/3 foot. Since 1/3 foot is represented by 1/3 inch on the scale and since there is no division at this point, you must estimate or mechanically divide the distance to obtain the measurement. Let us see how much easier it is to use the scale shown in the center of figure 2-18.

The numeral 1 located at the end of the scale identifies this scale as the 1 inch equals 1 foot scale. Notice that the zero index is located 1 inch in from the end of the scale. The major divisions are numbered 1 through 10. (Only the numeral 1 appears on the section of the scale shown. The numerals 20 and 18 are part of the 1/2 scale, which is read from the other end of the scale.) The section of the scale to the left of the zero index is divided into 12 major divisions which represent inches. This is the section of the scale that makes measuring in inches easy.

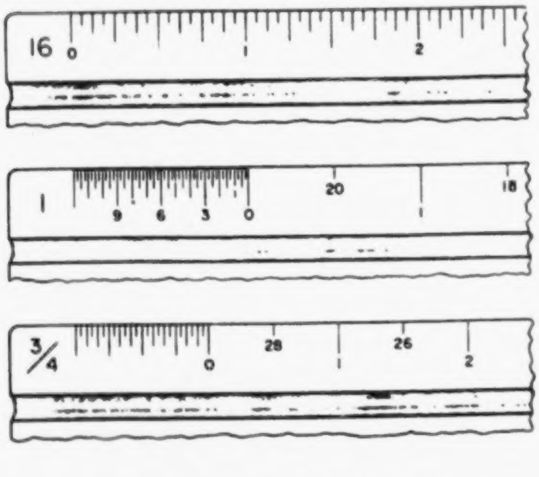


Figure 2-18. Sample sections of architect's scale.

To obtain the scaled measurement representing 5 feet 4 inches, all you have to do is place the unit division 5 at the right end of your measurement and mark the left end at a point opposite the fourth major division to the left of the zero index. This is more accurate than estimating and much easier than dividing the distance. In fact, with this scale you can make measurements down to 1/4 inch directly on the scale.

The bottom scale shown in figure 2-18 is used in the same way. On this scale, 3/4 inch represents 1 foot. Let us see if you can determine where you would mark the two ends of a measurement representing 2 feet 9 inches. If you selected the unit 2 division for the right end of your measurement and the third major division to the left of the zero index for the left end of your measurement, you are correct. If you did not get the measurement right, you should study the scale again.

Exercises (008):

1. What are the different types of scales?

2. How is each scale used?

3. What is meant by the term "open divided" when it is applied to the architect's scale?

009. Specify the features of erasing equipment.

Erasing Equipment. Erasers and other erasing equipment are important tools of the graphics specialist. Many drawings can be saved by a good job of erasing. Figure 2-19 shows some of the erasing tools a specialist uses. Probably the most important of these is the red ruby eraser. It is designed primarily for pencil corrections, but can also be used to remove ink. It will not destroy the surface of the paper if used properly, and this is especially important when you need to re-ink lines in the erased area. If the surface of the paper is damaged, the ink, when it is reapplied, will bleed or spread and ruin the drawing. Sometimes you can repair a damaged area by burnishing the area with a metal instrument or your fingernail.

Oil and moisture on the erasing surface will cause smudging. A pencil-type erasure will minimize the chances of transferring oils and moisture from your fingers to the eraser.

This is also true of the electric eraser. Electric erasers have the additional advantage of saving time, especially

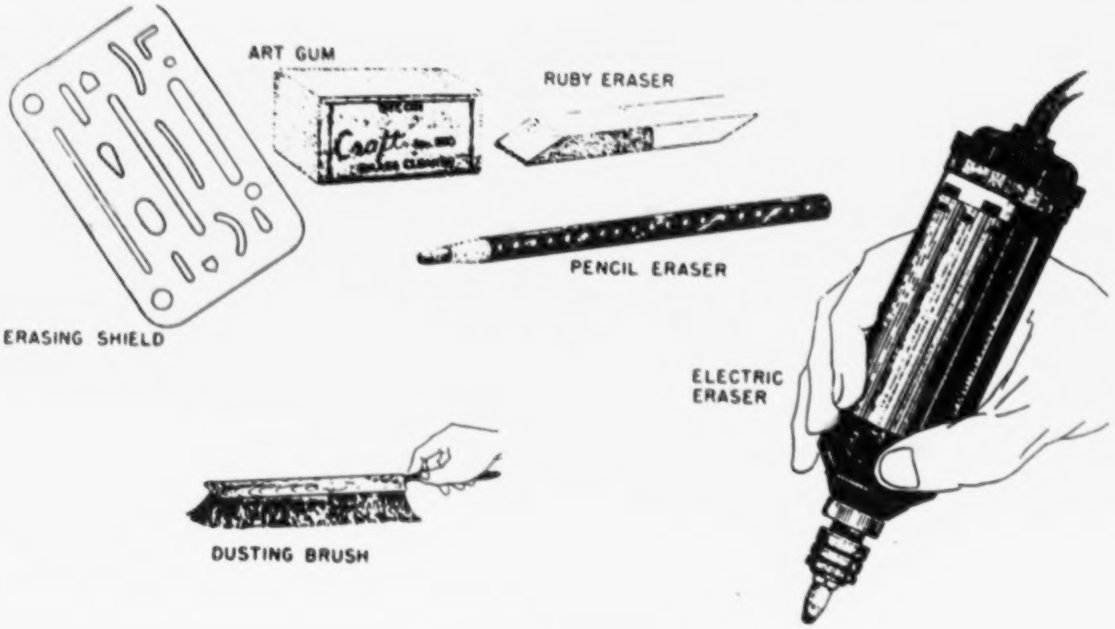


Figure 2-19. Erasing equipment.

when there is a considerable amount of erasing to be done. However, the erasing machine is difficult to use without damaging the surface of the paper, so exercise extreme caution when using one.

When erasing in an area containing many lines that are close together, you will find an erasing shield very useful. By placing the shield over the area so that the line which want to erase shows through the appropriate opening in the shield, you can erase the line without fear of damaging nearby lines.

An art gum eraser is generally used to clean up large areas. This cleanup job should be done before inking, because erasing over inked lines will destroy the luster of the ink. Deep black lines made with a soft pencil cannot be erased successfully with art gum, since soft pencil lines smudge very easily. It is far better to keep the drawing clean than to try to clean it with art gum after it has been soiled. The following suggestions, if observed, will help to keep the drawing clean:

(1) When moving the T-square, bear down on the head so that the blade is raised slightly from the paper.

(2) Your hands are always somewhat oily, so keep them off the paper.

(3) Use a hard pencil for layout work.

(4) Pick up the triangles rather than slide them.

(5) When finishing a drawing with a soft pencil, cover all areas except the one on which you are working, with a clean sheet of paper.

(6) Blow graphite particles that flake off the soft pencil from the sheet.

(7) Use a brush or soft cloth to brush erasing crumbs off the sheet rather than using the flat of your hand.

(8) Use a hard, smooth-surfaced paper if this is suitable for the type of drawing being made.

Many specialists also use kneaded erasers. These erasers are made from synthetic rubber or plastic and may be kneaded into a fine point or any shape that is advantageous to the specialist. They have the advantage of leaving few, if any, crumbs on the drawing, and can be used to pick up graphite dust rather than to rub it off. The kneading tends to incorporate the dust particles and cleans the eraser at the same time.

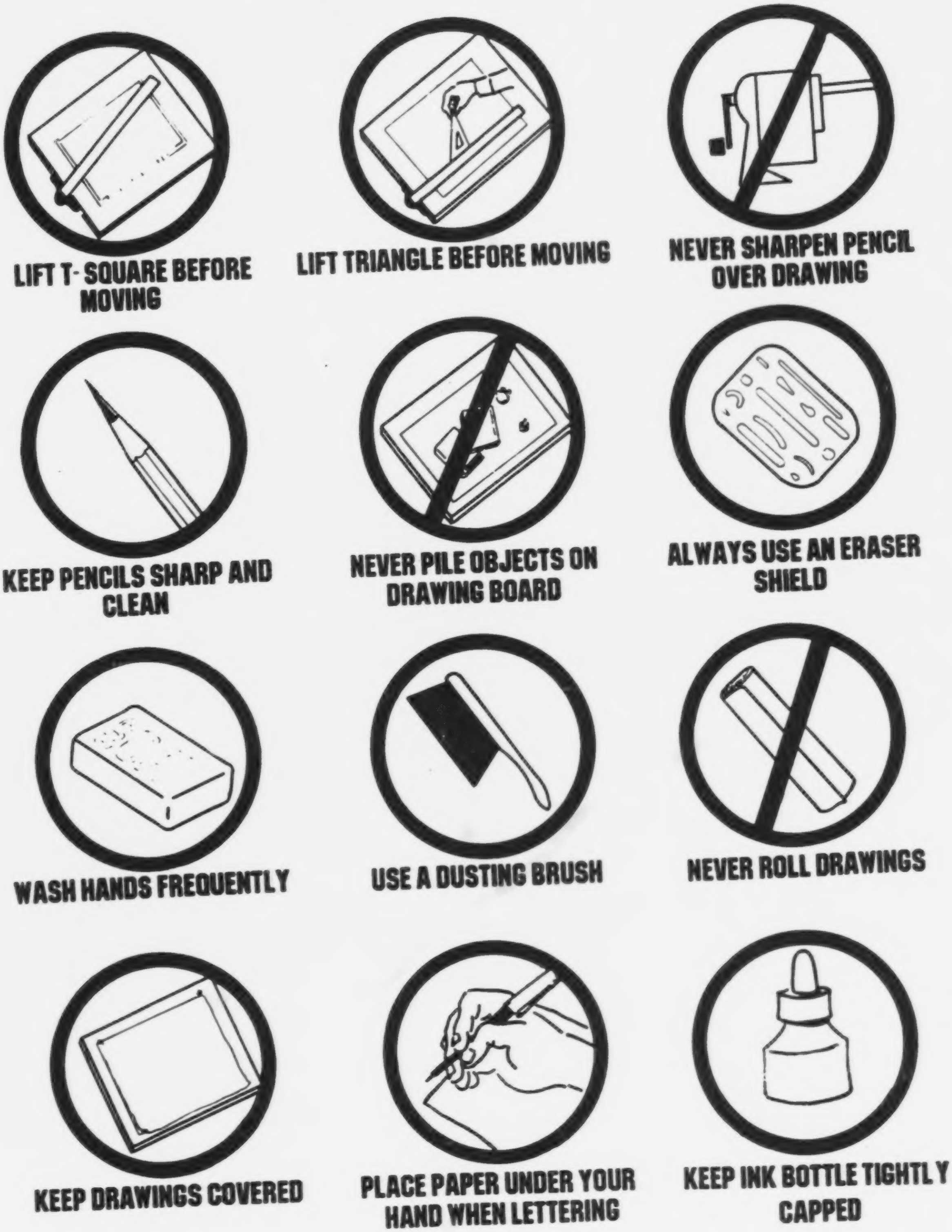
An eraser shield is a small plate of thin steel with holes of various shapes. The holes in the shield make it possible to remove unwanted lines while leaving other work untouched. Also, the sharp edge of the metal cuts away the smudged exterior of the eraser, permitting a clean eraser tip to be always on the drawing surface.

In addition to art gum erasers, cleaning compounds include pulverized gum eraser particles which may be squeezed from a plastic bottle or from a cloth bag. The granules sift through the bag as it is rubbed over the drawing. The eraser pad is also excellent for precleaning to prevent later soil buildup.

Figure 2-20 shows hints on how to keep your drawing clean.

Exercises (009):

1. What feature of the red ruby eraser makes it an important piece of erasing equipment?



LIFT T-SQUARE BEFORE MOVING

LIFT TRIANGLE BEFORE MOVING

NEVER SHARPEN PENCIL OVER DRAWING

KEEP PENCILS SHARP AND CLEAN

NEVER PILE OBJECTS ON DRAWING BOARD

ALWAYS USE AN ERASER SHIELD

WASH HANDS FREQUENTLY

USE A DUSTING BRUSH

NEVER ROLL DRAWINGS

KEEP DRAWINGS COVERED

PLACE PAPER UNDER YOUR HAND WHEN LETTERING

KEEP INK BOTTLE TIGHTLY CAPPED

Figure 2-20. Rules of neatness.

2. What features make the kneaded eraser unique?

3. What is the major disadvantage of an electric eraser?

010. Specify the characteristics of ruling pens.

Ruling Pens. A ruling pen consists of two steel blades attached to a handle. It is used to make straight ink lines of uniform thickness. The standard ruling pen, shown in figure 2-21,A, has an adjustable spring blade. A screw running through a hole in the adjustable blade screws into the stationary blade and is used to adjust the gap between the ends of the blades, which are called *nibs*. The width of the gap determines the thickness of the line that the pen will produce. Never tighten the screw far enough to bring the blades tightly together because to do so might bend the nibs and ruin the pen. The adjusting device also allows you to open the blade so that you can clean inside the nibs. Before you put the pen away, you should loosen the screw to relieve the spring tension.

The two other types of ruling pens, shown in B and C of figure 2-21, have hinged blades that allow the pens to be opened, cleaned, and snapped back into place without changing the width of the setting. These types of blades are very handy when you have a great deal of inking to do.

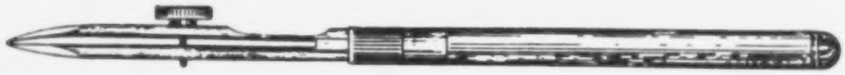
The spring pressure of the blades should be positive but not too strong, or it will cause the threads on the adjusting screw to wear out rapidly. Don't buy a pen with undue friction on this screw.

The wide-pointed pens, one of the two general types of points, are called detail pens. They serve best for drawing long, heavy lines since they hold more ink. Pens of any one type are specified by overall length. When buying a single pen, you should purchase one that suits your hand.

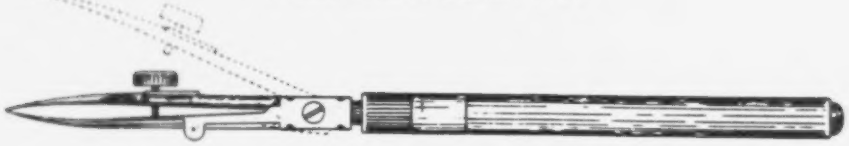
A ruling pen should be filled by placing the quill, which is in the stopper of the ink bottle, between the nibs of the pen and letting the ink run into the pen, as shown in figure 2-22. The ink should not stand more than 1/4 inch high in the pen, as the weight of a higher column will frequently cause the ink to run out and make a blot. After filling a pen, you should always make a test line on a piece of scratch paper. Be sure the ink flows properly and the width of the line is correct before you ink a line on a drawing.

The ruling pen should be held in the same manner as the drawing pencil. As shown in parts (a) and (b) of figure 2-23, the pen should be slightly inclined in the direction of motion and in a plane perpendicular to the paper through the line being drawn. You should take great care to get and to keep the pen in the correct position, since only a slight deviation is necessary to bring disastrous results.

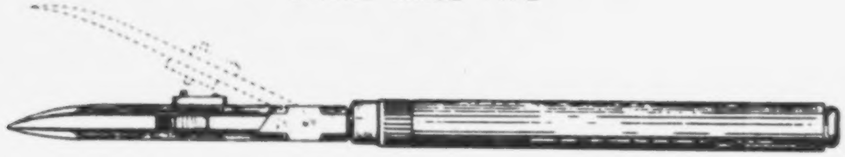
The four illustrations in the lower portion of figure 2-23 show the results of correct and incorrect manipulation of the ruling pen. The correct position of the pen and the resulting correct line are shown in the top illustration. Shown next is the result of applying too much pressure against the straightedge. As you can see, this forces the nibs together and thus reduces the thickness of the line. When the ink comes in contact with the straightedge and paper at the same time, it runs under the straightedge and blots the drawing, as shown in the third illustration. The same result will occur if you leave ink on the outside of the nib and it touches the straightedge. When the pen is held as shown in the bottom illustration, the outside nib of the ruling pen does not touch the paper and a ragged line is produced.



A.
PLAIN SPRING BLADE TYPE



B.
SPRING HINGE TYPE



C.
CLICK TYPE

Figure 2–21. Ruling pens.

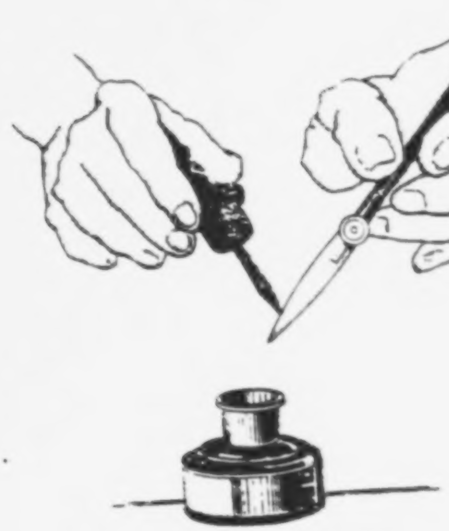


Figure 2-22. Filling a ruling pen.

To draw a long line, you should use a steady, even arm movement. Your little finger and ring finger should rest on and slide along the straightedge to help keep the angle of inclination constant. Just before you reach the end of the line, stop your arm and two guiding fingers and, without stopping the motion of the pen, finish the line with a finger movement. Draw short lines with this finger movement alone. When you reach the end of the line, quickly lift the pen from the paper and move the straightedge away from the line.

The quality of a line produced by a ruling pen depends not only on the manipulation of the pen but also on the condition of the point. Even the best pens seldom come from the manufacturer properly pointed. Therefore, you should learn to sharpen and shape the nibs. The correct shape is shown in part A of figure 2-24. Notice that it is not very pointed. A pointed tip produces a very high capillary action. This is the action by which the surface of a liquid is depressed or elevated as it comes into contact with a solid. This action holds the inkwell away from the point of the pen. A point of this type will not permit the ink to start, even on a broad line.

The equality in the length of the nibs is another condition that will affect the flow of ink. Before the ink will flow properly, both nibs must be equal in length, as shown in part C of figure 2-24. Part D of figure 2-24 shows what happens if one nib is longer than the other. Notice that the ink does not touch the paper and therefore doesn't flow.

After a few months of steady service, a good point will wear, producing a flat spot on the side that contacts the paper, as shown in figure 2-24,B. All three defects—sharp points, unequal length of nibs, and flattened points—can be corrected by proper honing on a fine grain oilstone.

The process of shaping the nibs of a ruling pen consists of two operations. The first operation consists of honing them to an even length and then rounding them off so that the end has a parabolic shape. This can be done by carefully closing the nibs of the pen and then rubbing the nibs over an oilstone, as shown in part A of figure 2-25. While rubbing the nibs over the stone, keep the pen in a plane perpendicular to the surface of the stone and rock it back and forth in the direction of motion. The second operation is that of sharpening the nibs. This must be done by grinding entirely from the outside, as shown in part B, until the edges of the nibs do not show any shiny flat spots when viewed edgewise. A magnifying glass is useful in making this examination. Exercise care in this operation to make the nibs equal in length and not so sharp that they cut the drawing paper. Under no circumstances should you attempt to sharpen the pen by honing the inside of the nibs. Sharpening it this way ruins the pen.

Exercises (010):

1. Why shouldn't the blades on a ruling pen ever be brought tightly together?

2. The wide pointed ruling pen is called a __________ pen.

3. What are the three common defects of used ruling pens?

4. Pushing the ruling pen with too much pressure against the straightedge causes what effect?

011. List the types of measuring instruments of a mechanical drawing set.

Compass. The large compass (fig. 2-26) is one of the most important instruments in a drawing kit. It should be adjusted before it is used for the first time and then maintained in that condition. As you can see, one leg is arranged to hold either a pencil attachment or a pen attachment. You should insert the pen attachment first and then adjust the needle point so that it is about 1/32 of an inch longer than the pen. Thus, when the needle point sinks into the paper, the pen is perpendicular to the paper; and when the compass is held in a vertical position, the pen barely touches the paper. Once you have adjusted the needle point, leave it in that position. When you change the pen attachment for a pencil attachment, adjust only the lead point. You use the same relationship as for the pen attachment.

The lead for the compass should be of the same grade as that used in pencil work. This means that you should keep several lead points on hand to suit the varieties of pencil

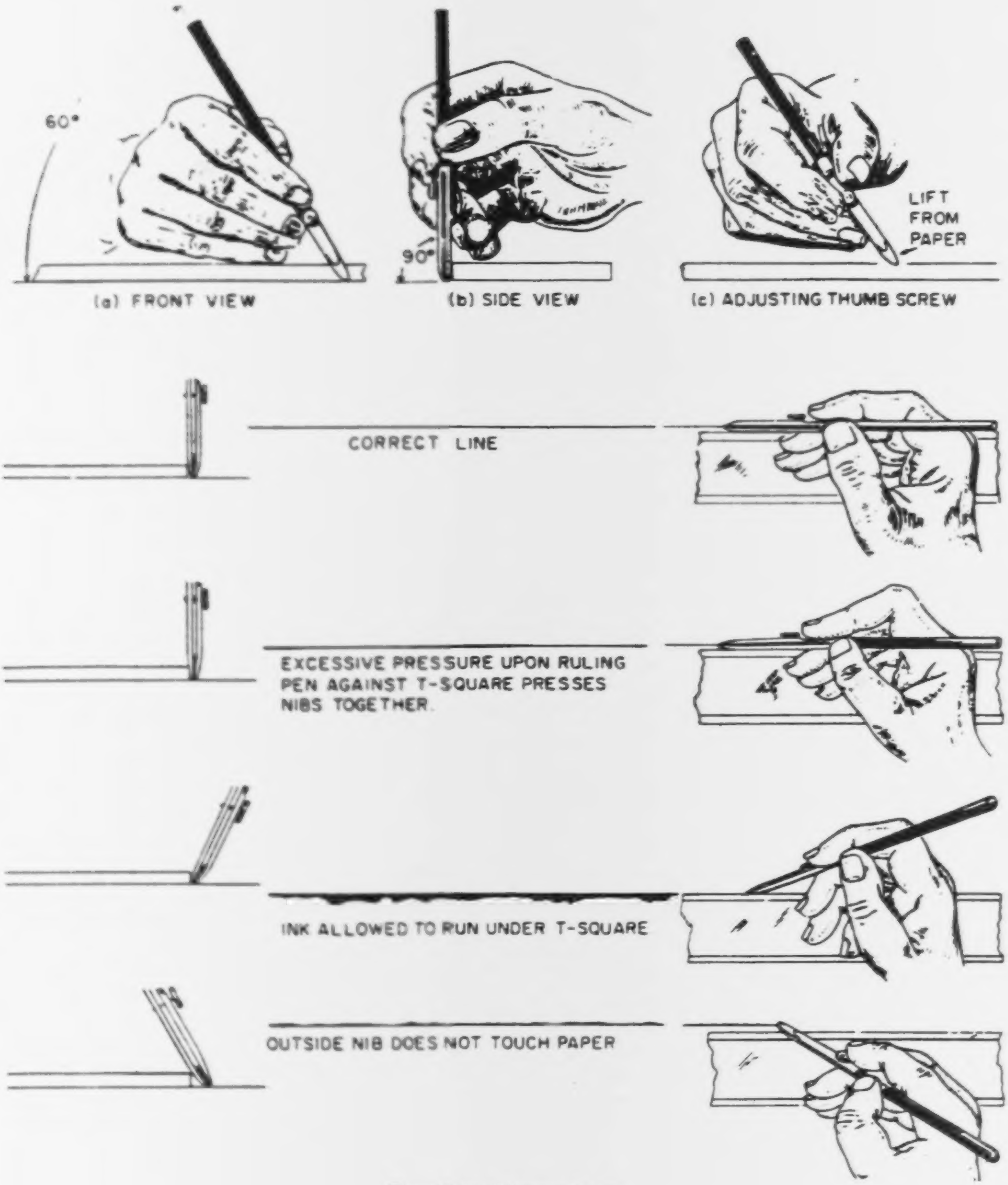

60°
90°
(a) FRONT VIEW
(b) SIDE VIEW
(c) ADJUSTING THUMB SCREW
LIFT FROM PAPER
CORRECT LINE
EXCESSIVE PRESSURE UPON RULING PEN AGAINST T-SQUARE PRESSES NIBS TOGETHER.
INK ALLOWED TO RUN UNDER T-SQUARE
OUTSIDE NIB DOES NOT TOUCH PAPER

Figure 2-23. Using a ruling pen.

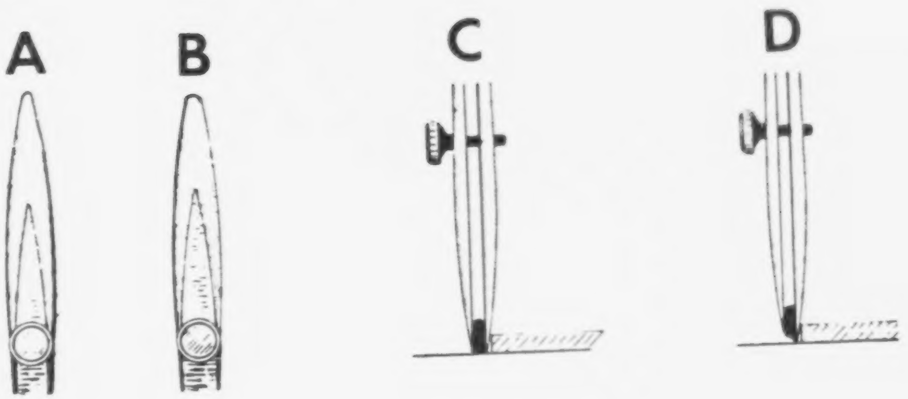


Figure 2-24. Correct and faulty ruling pen nibs.

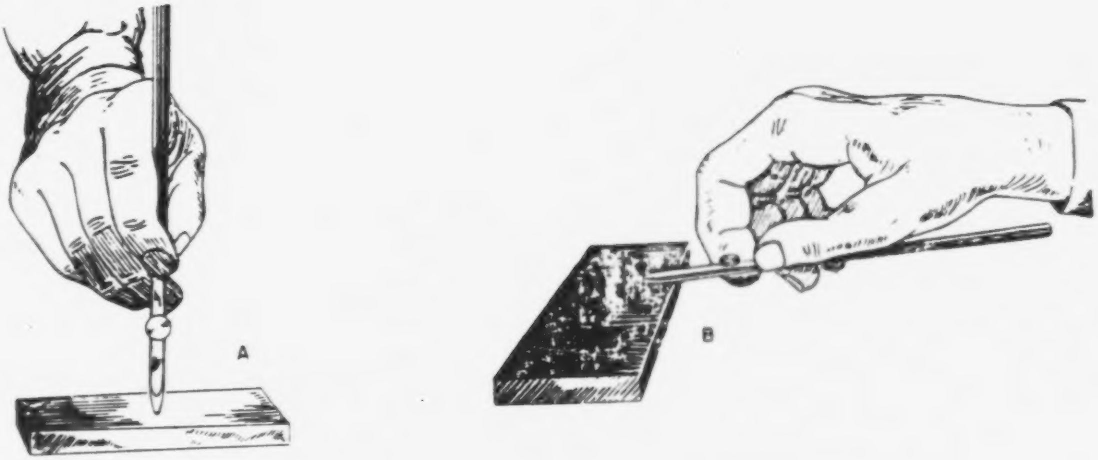


Figure 2-25. Equalizing the nibs and sharpening the ruling pen.

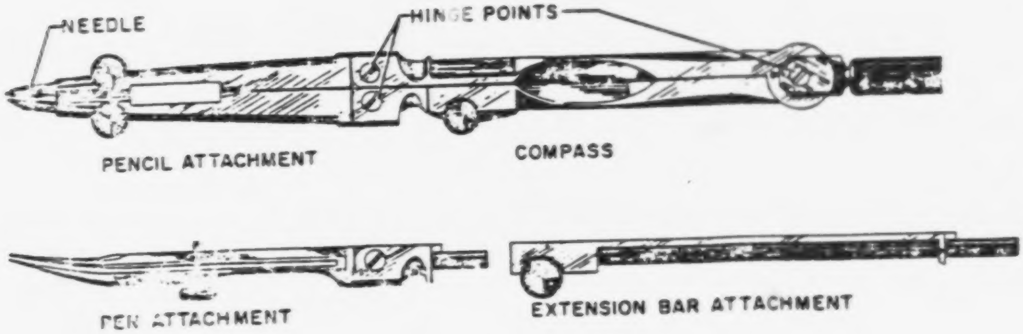

NEEDLE
HINGE POINTS
PENCIL ATTACHMENT
COMPASS
PEN ATTACHMENT
EXTENSION BAR ATTACHMENT

Figure 2-26. Standard compass with attachments.

used. You can sharpen the lead to a bevel point by sanding the outside edge (fig. 2-27). Sanding the outside edge of the lead permits you to sharpen the point without disturbing the compass setting even when the compass is set for drawing very small circles. With the bevel on the outside, the point of lead is nearer the needlepoint, thus permitting you to draw smaller circles.

When drawing small circles, you may leave the legs of the compass straight; but for large circles, bend the legs, as shown in part A of figure 2-28. The amount of bend depends on the size of the circle. Adjust the legs so that both nibs of the inking pen touch the paper when you hold the compass perpendicular to the paper. In this position the needle point will not create an unsightly hole when you draw several concentric circles. It is best to draw a circle with a clockwise movement and to go around the circle only once when inking. However, to secure a good black pencil line, you may find it necessary to retrace the circle several times.

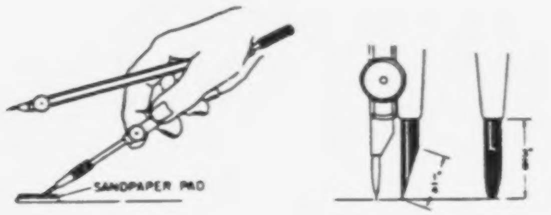


Figure 2-27. Sharpening and adjusting the compass lead.

For drawing circles larger than the compass will accommodate, you may add the extension bar attachment, as shown in part B of figure 2-28, or use a beam compass, as shown in part C. A beam compass consists of a bar, or beam, of metal 18 to 70 inches long, a steel needle point, and a pen or pencil point. You can slide the needle point and pen or pencil point. You can slide the needle point and pen or pencil point along the bar to any desired position and then tighten them against the bar with thumbscrews. Using the extended compass and beam compass requires more skill than handling a regular compass since both hands must be employed, one to hold the needle at the center and the other to move the pencil or pen point.

Dividers. Dividers are used chiefly for transferring distances and occasionally for dividing spaces into equal parts. They are similar to compasses except that both legs have needle points (fig. 2-29).

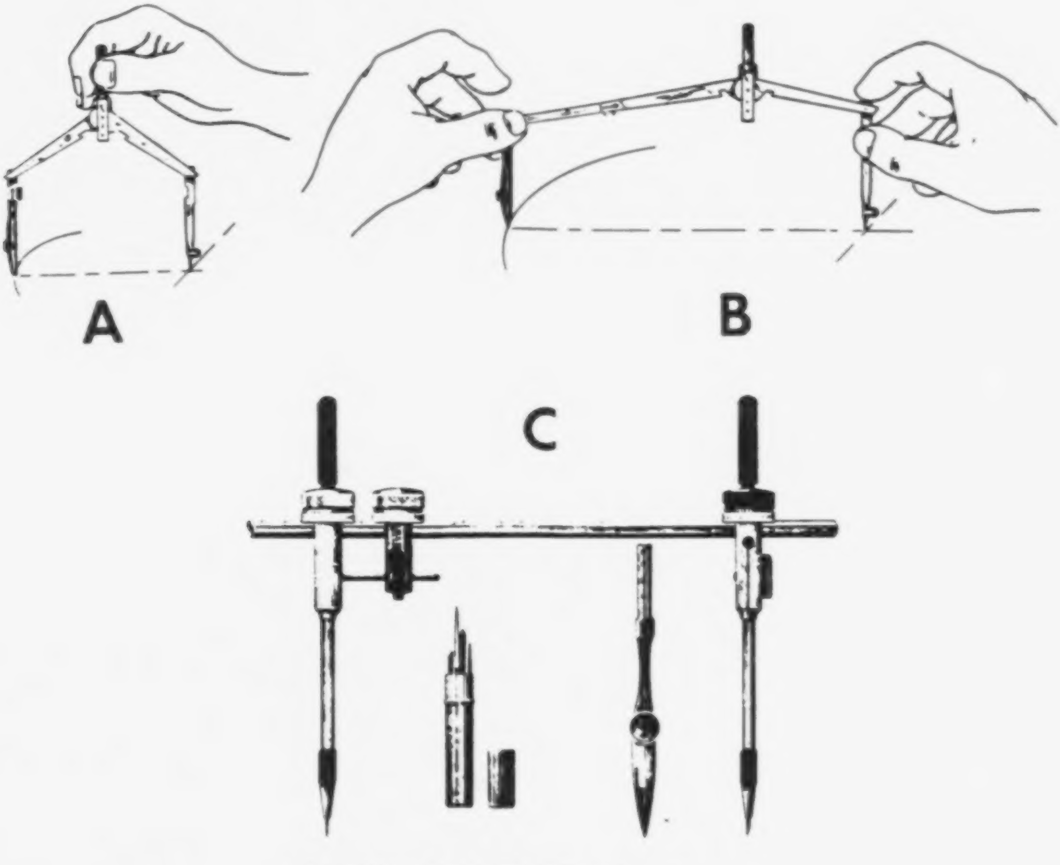


Figure 2-28. Extension bar compass and beam compass.

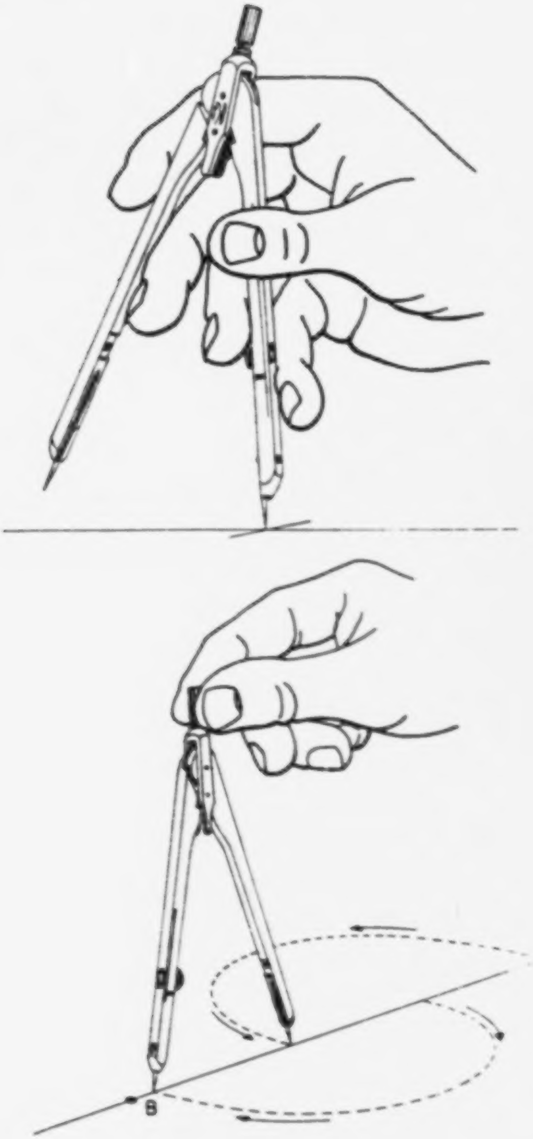


Figure 2-29. Adjusting and using the divider.

To set the divider, hold it in one hand. Then, if the distance to be set permits, hold it as shown in the top illustration. This permits you to increase the span by applying the pressure with your middle and ring fingers and to decrease the span by applying pressure with your thumb and index finger. If the distance is small, remove your fingers from inside the divider and close down the legs to the proper measurement by applying pressure with your thumb and fingers. A screw on one of the legs provides for a fine adjustment. To test dividers, close the legs and check to see if the two points come together in line with the legs.

To transfer a measurement from one drawing to another or from an object to a drawing, set the divider to the correct measurement and transfer the measurement to the drawing by pricking the drawing surface very slightly with the points of the divider. To step off a series of equal measurements, set the divider first clockwise and then counterclockwise, as shown in the lower illustration of figure 2-29. Alternately reversing the swing permits you to maintain your grip on the divider.

You can use dividers to divide a measurement into a number of equal parts by the trial and error method. The principle of this method is shown in the bottom portion of figure 2-29. If you want to divide the distance between points A and B into three equal parts, start by estimating one-third of the distance. Then set the divider for this distance; place one point of the divider on point A and step off three spaces along the line between points A and B. Be careful to prick the paper as lightly as possible. If the point of the divider coincides with point B, you have accomplished your objective. The two prick holes mark the division points of the line A–B. You may want to go back and make these holes slightly larger or mark them with a pencil to complete the operation.

If the point of the divider falls short of point B, as shown in figure 2-29, or overshoots it, you can use the distance of the undershoot or overshoot to determine approximately how much to change the setting of the divider for the next trial operation. In the above example, since you are dividing the distance between points A and B into three equal spaces, and the first trial setting was too small, increase the span of the divider by one-third the distance between the final position of the divider and point B. By repeating this trial operation, you will find the right setting.

An easier method of dividing the line shown in figure 2-29 includes the use of a *proportional divider* (fig. 2-30). This type of divider consists of two legs that are held together by a movable pivot section and which have a needle point on each end. The movable pivot section allows you to adjust the divider so that the span of the short needle points has a desired ratio to the span of the long needle points. The enlarged detail of this section shows how this is done. Notice that the knob on the underside of the bottom leg is geared to a rack on the inside of this leg. As you turn the knob, the pivot section slides along the inside of both legs. You can set the divider for a desired ratio by aligning the index mark on the movable slide with the graduation marks on the top leg. The divider illustrated in the enlarged detail of figure 2-30 is set with the index mark aligned with the 2/5 graduation mark. Therefore, the span of short needles will be two units when the span of the long needles is five units. After setting the divider for a certain ratio, lock the pivot point by tightening the locking nut on the face of the upper leg. This setting-and-locking operation is done with the legs of the divider closed. After locking the pivot point, you are ready to use the divider.

Now let us see how you would use the proportional divider to divide the distance between points A and B of figure 2-29. Since you want to divide the distance into three equal parts, you must first set the divider for a ratio of 3 to 1. You do this by setting the index mark opposite the indicating mark 3 and tightening the locking nut. Next, you

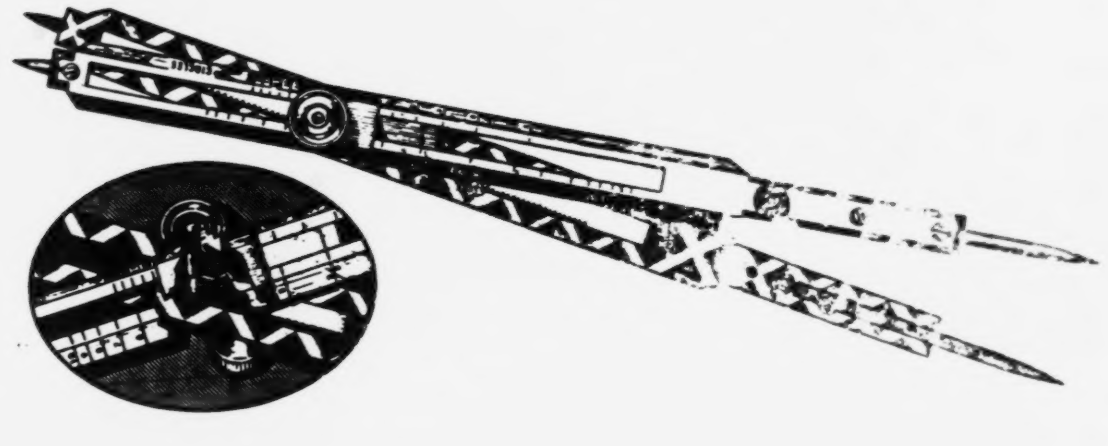


Figure 2-30. Proportional divider.

spread the legs of the divider until the long needle points will touch points A and B. Finally, you reverse the ends of the divider and step off the distances which divide line A–B, using the short needle points.

Notice that the proportional dividers shown in figure 2-30 are graduated for dividing circles as well as lines. To use them for this purpose, you set the right end of the index mark to the graduation line corresponding to the number of divisions desired. Then set the span of the long needles equal to the radius of the circle to be divided. Now you can use the short needle end of the divider to step off the divisions along the circumference of the circle.

Bow Instruments. A mechanical drawing set usually contains three bow instruments—a bow pen, bow pencil, and bow divider. Bow pens and pencils are used for drawing circles and circular arcs with smaller than 1-inch radii. Bow dividers, like regular dividers, are used for transferring measurements and dividing lines into equal parts but on a much smaller scale.

There are two types of bow instruments in general use. If the adjusting screw is on the side of the instrument, as shown in part A of figure 2-31, the instrument is called a *side bow*. If the adjusting screw is in the center, as shown in part B, the instrument is called a *center bow*. Both of these instruments are used in the same manner as the compasses and dividers previously described.

As you can see in figure 2-31, side bow instruments are merely small instruments which have a thumbscrew acting against the spring tension of the legs. The screw threads on these instruments are delicate; therefore, do not force them. You can decrease the wear on the threads by holding the legs together lightly as you turn the adjusting screw. This applies only to the side bow instruments. You should keep the threads of both types of instruments free from rust and dirt.

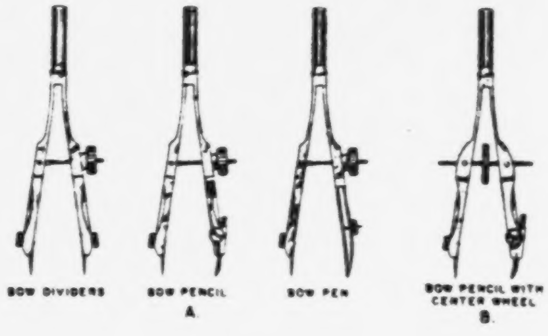


Figure 2–31. Bow instruments.

Exercises (011):

1. List the two types of measuring instruments of the drawing set.

2. What are proportional dividers?

3. How many bow instruments does a mechanical drawing set contain?

4. Why must the leg containing the needle point be kept perpendicular to the paper?

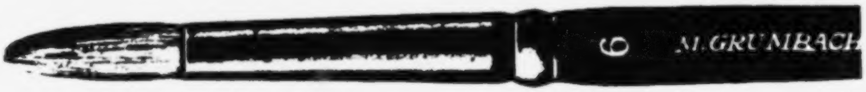
012. List the types of brushes and state their characteristics.

Brushes. One of the most versatile tools that you will ever use is a brush. A brush is basically a clump of straight, fine hairs attached to a slender wooden handle. Brushes are used to transfer any liquid or semi-liquid medium to any working surface.

The brushes that we use are a bit more sophisticated than the hair on the stick example. Brushmaking has evolved into an exacting craft. The hair of bristles are hand-selected, hand-trimmed, and hand-set. It takes years of experience for a person to become a qualified brushmaker.

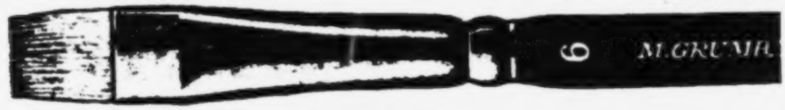
There are several kinds of hair used to make brushes. Camel hair brushes are too soft and do not have sufficient elasticity or "life" for average professional purposes. An inferior grade of sable is preferable to any camel hair.

The best brushes are called *red sable*. The one source of hair for these brushes is the tail of the Kolinsky (known also as the Siberian mink or the Tartar marten). No other hair has the same springiness or durability. This hair is delicately tapered, and the tip is slender and comes to a fine point. Beyond its widest point, or "belly," the hair tapers somewhat toward the boot. Some brushes are set so that the opening of the ferrule grips the belly; others are gripped above or below this point. The character of the point varies according to the place at which the hairs are gripped (fig. 2-32).



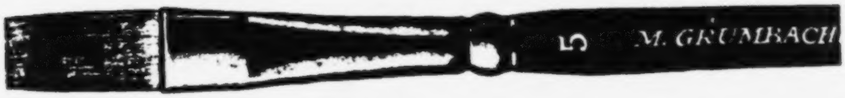
ROUNDS

ROUNDS are completely round with pointed ends.



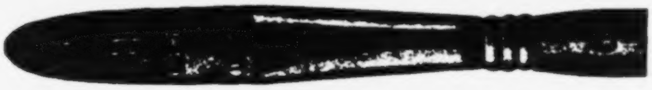
BRIGHTS

BRIGHTS are short, square end brushes.



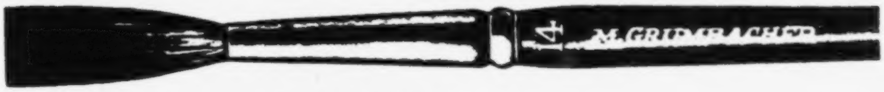
FLATS

FLATS are similar to brights but have longer hair or bristle.



FILBERTS

FILBERTS are similar to brights or flats in length but have oval shaped tips.



LETTERING

Figure 2-32. Types of brushes.

There are five types of brushes: rounds, brights, flats, filberts, and lettering brushes. The rounds come to points which vary from fairly sharp to quite blunt. The brights are flat, have rather sharp corners, have less thickness of bristle, and their length is about 1½ times their width. The flats are broad with flattened ferrules and straight edges, and they have a bristle length that is about 2½ times their width. Filberts are similar to the flats except that the width of the bristles is wider at the base and narrower at the ends. Lettering brushes have very long bristles that are somewhat flattened to allow a smooth flow of lettering medium. These long bristles also absorb the natural shakiness of your hand and let you achieve a smooth stroke.

Brushes are expensive, so treat them kindly. A well-kept brush performs better and lasts longer than a mistreated brush. Here are some hints that will help you keep your brushes in top shape:

a. Always clean your brushes after you use them. Use the proper solvent for the type of paint used. After the paint is cleaned out of the bristles, wash the brush in warm water and a mild soap. Make sure the brush is rinsed CLEAN.

b. Load the brush with soap, and shape the bristles to their original shape.

c. Store the brushes in an open jar. Place the handles down and leave the bristles up and exposed to the air. In this position, the bristles are not resting in contact with any surface, and there is less possibility of their becoming distorted.

Exercises (012):

1. What is the one source of red sable bristles?

2. What varies the character of the brush?

3. List the five types of brushes.

4. What is the proper method of storing brushes?

CHAPTER 3

Fundamentals of Lettering

THE THOUGHTS or ideas the graphics specialist wishes to pass on to someone else are seldom conveyed by illustrations alone. Most illustrations are accompanied by some form of written word. The words may take the form of a title, which usually tells something about the illustration, or they may be included as an integral part of the illustration. You can see this by looking at the advertisements in any magazine or newspaper. Illustrations used by the Air Force are not exceptions. This means that you, as a graphics specialist, must be able to letter as well as illustrate. In fact, you will find that a fair illustration with good lettering is more effective than a good illustration with poor lettering. In other words, the lettering can make or break an illustration. We might say also that being able to letter well can be the difference between a good graphics specialist and a poor one. One thing for sure, if you learn to letter well, you will be of great value to any graphics organization regardless of your other qualifications.

Lettering, like drawing, is an art. As in other arts, you must spend many hours studying and practicing to acquire the necessary knowledges and skills. This course cannot help you develop your skill. You must gain that by continuous practice. It can, however, present helpful information on the fundamentals of lettering. From this chapter, you should learn the basic principles of lettering, how each letter is formed, what constitutes good spacing, how to obtain good spacing, how to letter by hand and by using mechanical lettering equipment, and how to use prepared lettering. Let us start with lettering fundamentals.

3-1. Lettering Styles and Nomenclature.

Lettering produced by hand without mechanical lettering aids of any kind has a quality that cannot be obtained by any other means. It takes on the personality of the individual letterer as well as the character of the instrument used to produce it.

The ability to letter well can be acquired only by continued and careful practice. Anyone with muscular control of his or her fingers can acquire this ability if he or she will practice faithfully and intelligently and take the trouble to observe carefully the shapes of the letters, the sequence of strokes used to make the letters, and the rules for letter composition.

The alphabet we use today had its origin in ancient hieroglyphics. After being developed by the Egyptians into a cursive form, it was adopted by the Phoenicians, who produced an alphabet of 22 letters. This alphabet was transmitted in the course of time to the Greeks and by them to the Romans. Each of these civilizations made changes in the alphabet due in part to the kinds of tools and materials they used in recording their writings. The Roman capital alphabet finally evolved and has come down to us practically unchanged. Except for small letters, which were added to the Roman alphabet by the master printers of Venice after printing had been invented in Germany in the 15th century, most newspapers, magazines, and books of today use letters which differ very little from those carved on Roman architecture over 2000 years ago. The success and durability of the Roman alphabet can be attributed to the fact that the letters are based on well-defined principles and geometric truths—the circle, ellipse, vertical lines, horizontal lines, and diagonal lines being the elements.

013. Specify the styles most used in modern printed material.

Styles of Lettering. Through the centuries, writing styles and even the basic letter forms were changed and modified due to the materials used and the tendency of men to try to find easier ways of doing something. Printing imposed certain changes toward a more mechanically perfected letter form. This began a trend toward simplicity and ease of construction.

Text. The first type faces were simply copies of the manuscript lettering of the period. The Gutenberg Bible, the first printed book, was printed in an angular, northern block letter. A number of type faces based on the old block-letter or text alphabets, such as the German Text and Old English Text, are still used. For those of us who are accustomed to simpler styles, the text style of lettering is quite difficult to read. Therefore, we seldom use this style for blocks of copy. Text lettering is used often for formal and decorative purposes on certificates, formal announcements, diplomas, etc.

Gothic. In this style all parts of the letters are of equal width. When the width of the strokes can be made with a single stroke of a lettering pen, pencil, or brush, the style of letter is called ***single-stroke*** Gothic. When the outline of a letter is drawn and the area between is filled in, the style is called ***filled-in*** or ***built-up*** Gothic.

Roman. The style of alphabets in which the letters are produced by thick and thin strokes is classified as Roman. The thick and thin strokes of this style give variety and letter characteristics which are easy to read; therefore, Roman style lettering is widely used. In fact, most books, magazines, newspapers, and other written means of communication use this style of print.

Each of the three styles of lettering may be further subdivided into capital letters, or uppercase, and small letters, or lowercase. The terms "lowercase" and "uppercase" evolved from the printing trade. Before the advent of modern printing, printers had to hand set their type. They used a letter case with compartments to keep the different letters of a font (complete set of type) separated from each other. The small letters of a font were kept in the lower part of the letter case and the capital letters were kept in the upper part of the case. Thus, lowercase and uppercase became common usage for small and capital letters.

The printers and manuscript writers of Italy added another characteristic to the style of lettering. They used a slanting stroke instead of a vertical stroke in their letter design. This distinguishing characteristic resulted in the adoption of the term "italic" for all letters having this characteristic slant.

Styles of letters can also be distinguished by their general proportions. Although there is no standard for the proportions of letters, there are are certain fundamental points in design and certain characteristics of individual letters that you must learn before you attempt to compose letters into words and sentences. Not only do the widths of letters in any alphabet vary, from I, the narrowest, to W, the widest, but different alphabets vary as a whole. Styles narrow in their proportion of width to height are called *compressed* or *condensed* and are used when space is limited. Styles wider than normal are called *extended* lettering.

The proportion of the thickness of stem to the height varies widely, ranging from 1/3 to 1/20. Letters with heavy stems are called *boldface*, and those with thin stems are called *lightface*. Thus, besides the three main items used to designate any style of letter (basic form, uppercase or lowercase, and vertical or slant), terms such as single-stroke or filled-in, condensed or extended, and boldface or lightface are also used.

Exercises (013):

1. What are the styles of lettering most used today?

2. What changes did printing have on lettering styles?

3. Letter styles narrow in their proportions of width to height are called________ or ________ letters.

4. Styles wider than normal are called ________ lettering.

014. State the parts and characteristics of letters.

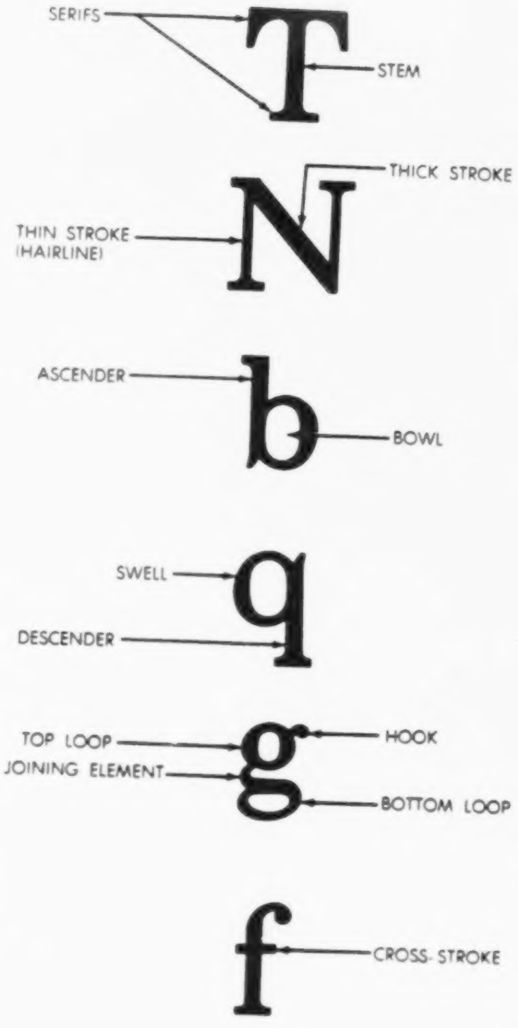


Figure 3-1. Letter nomenclature.

Letter Nomenclature. Before we go further into letter fundamentals, we should go over the names of the various parts of letters. This will give us a common language to use in discussing lettering principles. The different parts of letters are designated in figure 3-1. You are probably familiar with some of these names, but let us go over them to make sure that you know all of them.

The two parts, *serif* and *stem*, shown on the top letter, should be familiar names. The *serif* is a thin, short finishing stroke at the top and bottom of letters made with straight vertical or horizontal strokes. Serifs are a characteristic of Roman letters. The *stem* of a letter is the name for the straight vertical line that is used as a basis for most letters of the alphabet.

The next letter of figure 3-1 shows two names that are often used to describe parts of letters. When a broad nibbed pen is used to construct letters, it is usually held so that the nib is parallel with the line of lettering. Therefore, when a downward stroke is made, the part of the letter produced is a

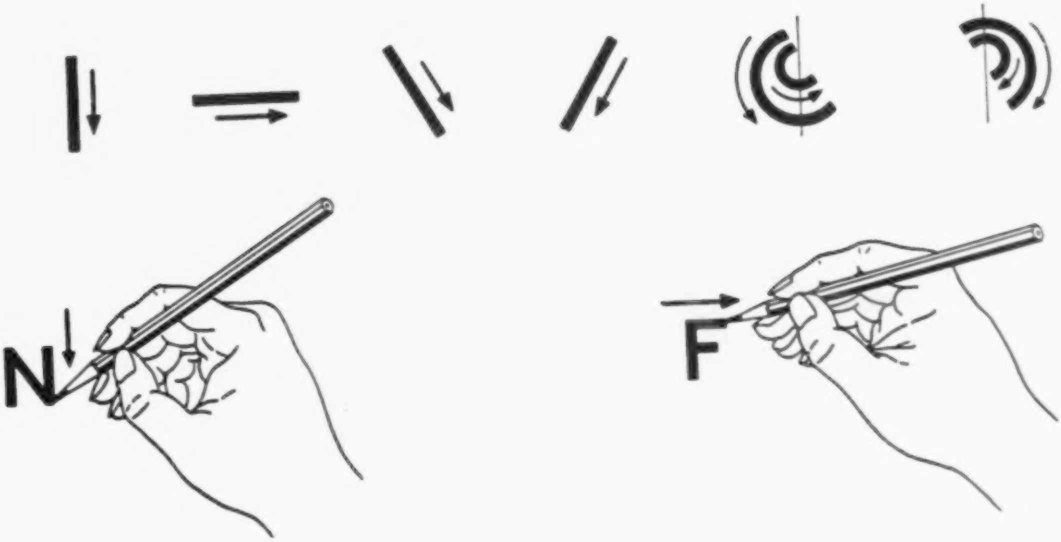


Figure 3-2. Basic lettering strokes.

thick stroke. Naturally, a thin stroke is produced when the pen is moved horizontally or is turned so that the nib is moved edgewise down the paper as in the construction of the letter N. Sometimes we refer to the thin stroke as a *hairline*.

The next two letters in figure 3-1 are quite similar, so we can discuss their nomenclature together. The stem of a lowercase letter that extends above the body of the letter is called the *ascender*, and the portion of a lower case letter that extends below the body is called the *descender*. The combination of the ascender or descender and the body of a letter is the same height as a capital letter. The white area inside of a letter made with a curved stroke is called the *bowl* or the *counter* of the letter. The curved portion of such letters is called the *swell*. The swell is often made slightly wider than the stem because it is thick only at one point, and appears thinner than the stem when made the same thickness. This is apparent in figure 3-1 where the swell is the same thickness as the stem.

Now let us look at the last two letters in figure 3-1. As you can see, the letter "g" has many additional parts with different names. However, the names are self-explanatory and need no further explanation. The final part of letters shown in the figure is the cross-stroke. This is the thin horizontal stroke of the lowercase letters f and t and capital letters A and T. Sometimes it is used to refer to the horizontal strokes of the capital letters E and F.

Exercises (014):

1. What are the seven parts of letters?

2. Serifs are characteristic of what type letter?

3. What is the curved outer portion of a lowercase letter called?

3-2. Letter Formation

There are three necessary steps in learning to letter. You must know the proportions and forms of the letters, the order of the strokes used to produce each letter, and composition—the spacing of letters and words.

015. List the two elements and the six basix strokes of lettering.

Elements of Letters. The letters of the alphabet are composed of two simple elements, with a few variations due to the shape of certain letters. The first of these elements is called the stem of the letter and is made with a single downward stroke. The second element is called the round or oval and is made with one or two strokes, depending upon the size of the letter being made. The basic strokes used to produce these elements are shown in figure 3-2.

Stems. The straight lines, vertical or slant, which form a part of more than four-fifths of all the letters of the alphabet, are called the stems. This term does not apply to those horizontal straight lines which form a part of such letters as A, E, F, and H. The following rules are applicable in forming all stems:

a. The stems are uniform in weight or thickness and have uniform height. When using a pen to produce letters, the width of the stroke is determined by the kind and size of the pen being used rather than the amount of pressure applied to the pen.

b. The stems are perfectly straight without hooks or curls at either end.

c. The slopes of the stems are uniform and parallel to each other throughout any piece of lettering.

Rounds or ovals. The second element in lettering is a perfect circle or a perfect ellipse with a well-determined ratio between its major and minor axes. A good proportion for width to height is 5 to 6. That is, the width of a parallelogram

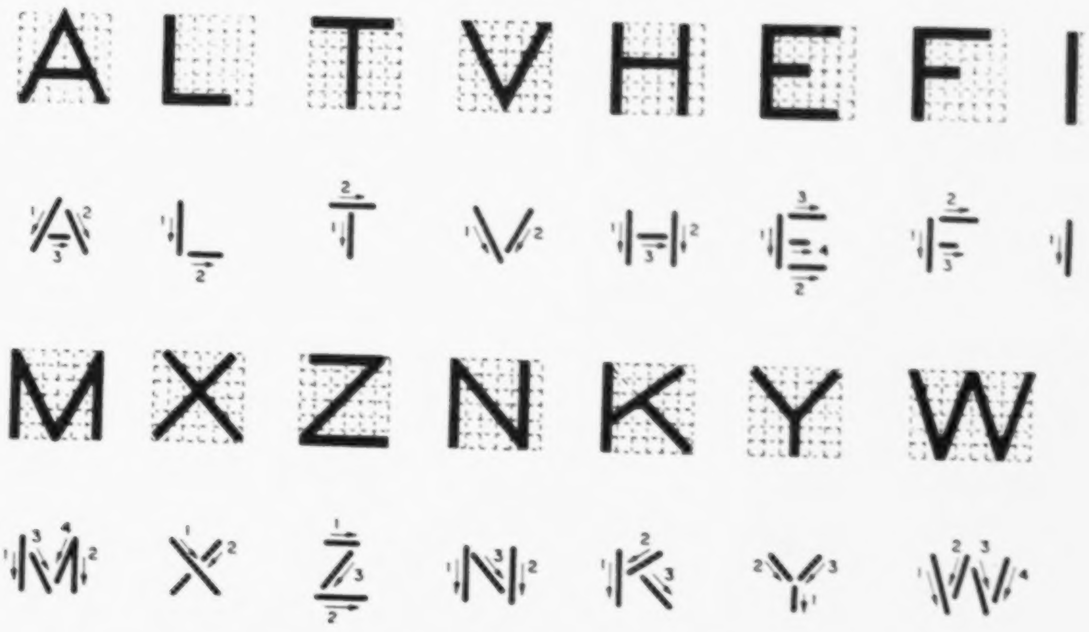


Figure 3-3. Vertical straight line capitals.

inclosing the ellipse should be five-sixths the height. The ellipse should touch the four sides of the parallelogram at their midpoints. These proportions give what is termed a standard vertical or slant oval which, when properly combined with the stem, produces the normal or standard letter.

Combination of stem and oval. When you have mastered the technique of the individual elements, it becomes a simple task to combine the elements to form such letters as a, b, d, n, r, and u. The secret of success lies chiefly in remembering that the stem becomes one side of the parallelogram. In making the stem tangent to the ellipse,

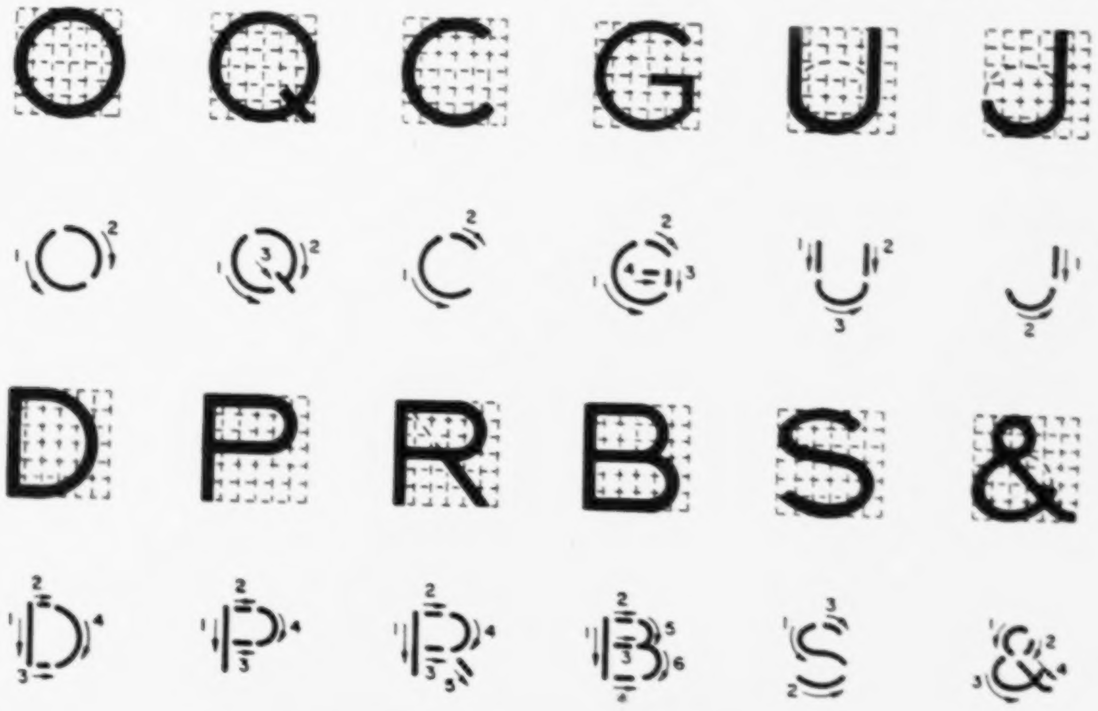


Figure 3-4. Curved and curved straight line combination capitals.

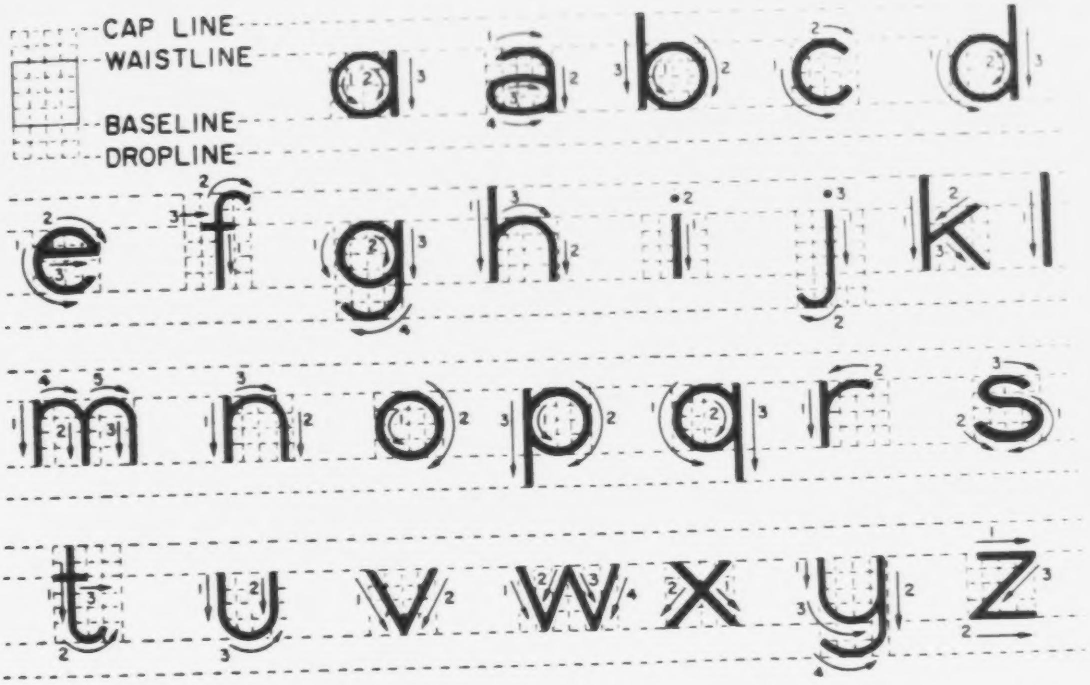


Figure 3-5. Vertical lower case letters.

remember that they must coincide with each other, but in no case should the thickness of the letter at the point of tangency be permitted to become greater than the thickness of the stem.

Capital Letters. In learning the form of each letter and the sequence of stroke used to make each letter, let us begin with the capital letters that are made entirely of straight lines. These letters are shown in figure 3-3. Notice that, except for the W and the I, the letters have been placed within a parallelogram which is divided into six equal spaces both horizontally and vertically. The letter I, being the basic vertical stroke, makes it possible for you to determine the width of each letter at a glance. The strokes with arrows beneath each letter show the direction and order of strokes used to make each letter. As you can see, the strokes are usually made from top to bottom and from left to right.

The position of the crossbar on the A, H, E, and F is an important consideration. Notice that the crossbar of the A is placed below the vertical center and that the crossbar of the H is slightly above the center. This is done to avoid a top-heavy appearance. Although it is not shown in this figure, usually the crossbar of the E and the crossbar of the F are raised slightly to improve the appearance of these letters.

Next, let us look at the wide letters M and W. The first and last strokes of the letter M are vertical, and the center section of the letter is the same as the letter V. The alternate strokes of the letter W are parallel. Notice that the two V-shapes used in its construction are narrower than a normal V.

We should also discuss the characteristics of the letters X, Z, K, and Y. The strokes of the X cross slightly above the center. This produces a slightly narrower width at the top of the letter than at the bottom and adds stability. The letter Z is stabilized by making the top stroke shorter than the bottom. Notice that the third stroke of the letter K, if extended, would pass through the top of the first stroke. The appearance of the letter Y is improved by making the branch of the letter below the vertical center.

Now, let us look at the letters formed by curved lines and combination of curved and straight lines. These are shown in figure 3-4. The only letters of this group that need special mention are the letters P, R, and B. The center horizontal line of these letters is usually drawn slightly above the vertical center, and the top of the R and B is smaller than the lower part to give the letter stability. (This is also true of the top and bottom curves of the letter S.) Notice that the letters P, R, and B appear somewhat squatty. Their appearance can be improved by making them one square narrower.

Small Letters. Seven of the small, or lowercase, letters are made with straight lines. Two are made with curved lines, and the remaining letters are constructed with a combination of curved and straight lines. The lowercase letters of a Gothic style alphabet are shown in figure 3-5. As you can see, the bodies of these letters are two-thirds the height of the capitals; and the long stems or ascenders, with the exception of the letter t, which is generally shorter, are the same height as the capitals. The descenders of the letters g, j, p, q, and y extend as far below the lower guideline as the ascenders extend above the body of the letters.

Numerals. Figure 3-6 shows the numerals used with a Gothic style alphabet. Notice the similarity between the bottoms of the 3, 5, and 8 and between the top of the 2 and 3. The top of most numerals is smaller than the bottom. The height of numerals is always equal to the height of the capital letters.

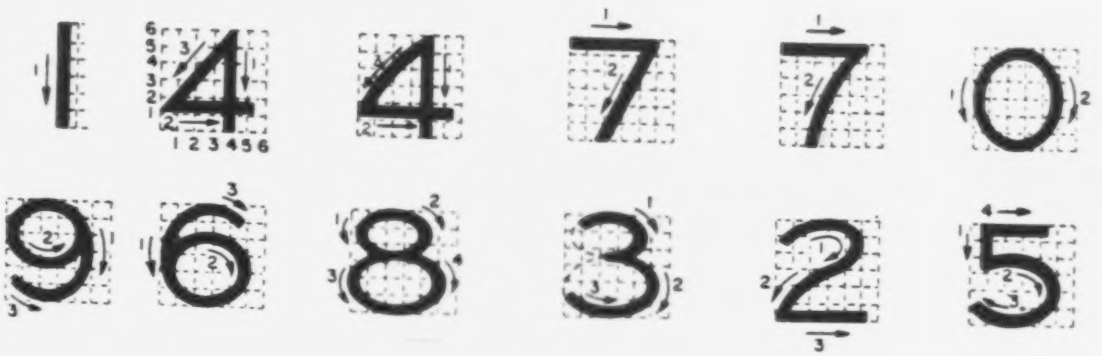


Figure 3-6. Numerals.

Inclined Letters. Inclined or italic letters are made with the same number of strokes and in the same sequence as vertical letters. Figure 3-7 shows some of the things you should know about inclined lettering. The stems of slanted lettering are sloped so that they make an angle of 67½° with the horizontal guideline. This makes the major axis of curved letters slope at a 45° angle. Figure 3-8 shows the form of the capitals, lowercase, and numerals of an inclined Gothic alphabet. Compare these with the vertical alphabet which you have just completed studying.

Roman Style Letters. Since Roman style lettering is made with thin and thick strokes, the primary concern when constructing this style of letter is the placement of the heavy and light strokes. For example, a very common error for beginners is to place the thick portion of an A on the wrong side. They darken the left slope rather than the right slope. Let us see if we can find a rule to determine which strokes should be light and which strokes should be heavy.

The design of the Roman alphabet (see fig. 3-9) is based on the reed pen used during its development. Since the nib of this type of pen is wide and is held parallel with the horizontal lines of the paper, a downward stroke produces a broad line and a horizontal stroke produces a thin line. A rule stating that downward strokes should be thick and horizontal strokes should be thin works fine for the letters B, C, D, E, F, G, H, I, J, L, O, P, Q, R, and T, but does not work for the letter U or with letters containing diagonal lines.

Let us see why this rule does not work with letters containing diagonal lines, starting with the letter N, shown in the upper left corner of figure 3-9. If we used this rule there, both vertical lines and the diagonal line would be thick. This would produce a letter out of character with the other letters. If we made the two vertical lines thick and turned the pen and made the diagonal line thin, we would have a letter with much the same character as the letter H, but one which would be very weak in design. The thick vertical strokes would have a tendency to divide the letter and would appear as part of the preceding and succeeding letters. Therefore, the diagonal of the N is made thick and the pen turned sideways to make the vertical strokes thin. This gives the N the right characteristics and produces a strong, well-designed letter. The last vertical stroke of the U is made thin for the same reason.

As you can see in figure 3-9, the letters A, V, Z, X, Y, M, W, and K also contain diagonal lines and deserve special consideration. With the exception of the letter Z, all diagonal lines which are made downward from left to right are thick and those made downward from right to left are thin. You do not even have to remember which is thick and which is thin. Just try drawing them. Notice how much easier it is to turn the pen to make the right-to-left diagonals thin than it is to make the left-to-right diagonals thin. However, you will have to twist your wrist considerably to make the thick stroke of the letter Z.

We have several other suggestions to offer you in regard to his Roman style of letter. The beauty depends to a great extent upon uniform, clear-cut spurs or serifs, and a uniform stroke of all the characters. Notice that the serif is made with a thin horizontal line across the end of each thick and thin stroke and with circular arcs rounding off the area between the flat edge of the serif and the stem of the letter. Notice that the flat portion of the serif extends beyond the stems and that the arcs do not extend to the end of the serif. They become tangent midway between the edge of the stem and the end of the serif.

The width of the round or oval stems of such letters as O, C, G, and D is slightly greater than the straight stems. Since the round or oval stem is full width at one point only, it will appear narrower than the straight stem if it is not made

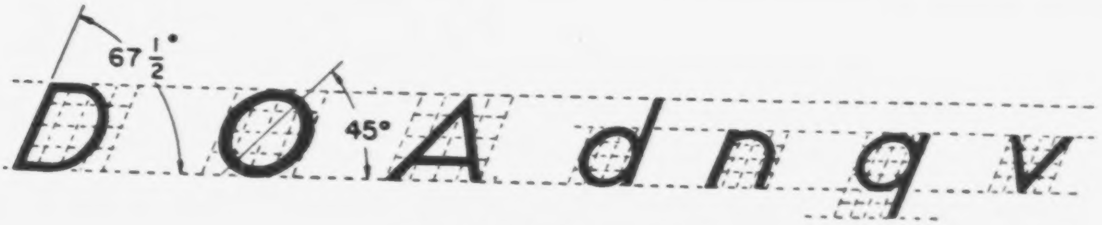


Figure 3-7. Inclined letter formation.

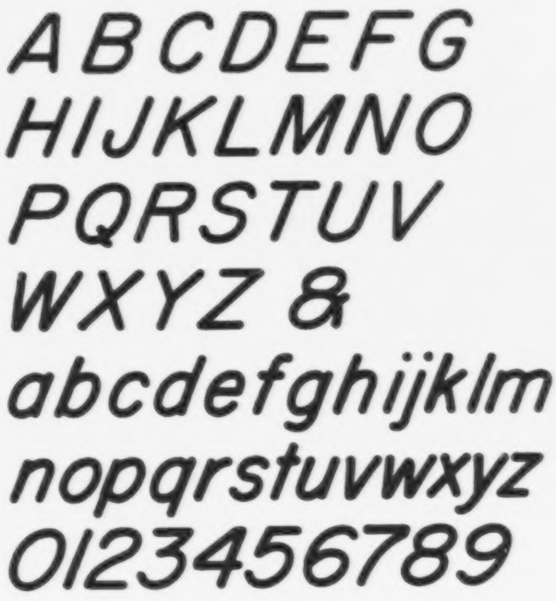


Figure 3-8. Inclined letters and numerals.

slightly wider at this point. Round letters, such as the O, C, and G, and pointed letters, such as the A and V, are affected by the same optical illusion. The round parts of letters and the pointed parts of letters should extend slightly beyond the guidelines to overcome this illusion; otherwise, these letters will appear smaller than the other letters.

The dimensions of the letters shown in figure 3-9 are based on the width of the stem. As you can see, these capital letters are seven units high and vary in width. Study them until you are familiar with each letter and its dimensions; then use figure 3-10 to become familiar with the lowercase letters. Notice that the long stems of the small letters are equal in height to the capitals but are slightly narrower in width. Using a narrower width for small letters gives them the same general appearance as the capitals.

Exercises (015):

1. What are the two elements of lettering?

2. What is a stem?

3. What are the six basic strokes that are used in lettering?

4. What is the standard slope of inclined letters?

5. Why should the point of the letter A extend slightly beyond the guidelines?

3-3. Principles of Lettering

To be effective, lettering must be legible. This means that the letters must be well-proportioned, stable, uniform, and properly spaced. We have already discussed proportions of letters during our discussion on forming letters. Let us review and add to this information.

016. Specify the three principles of good lettering.

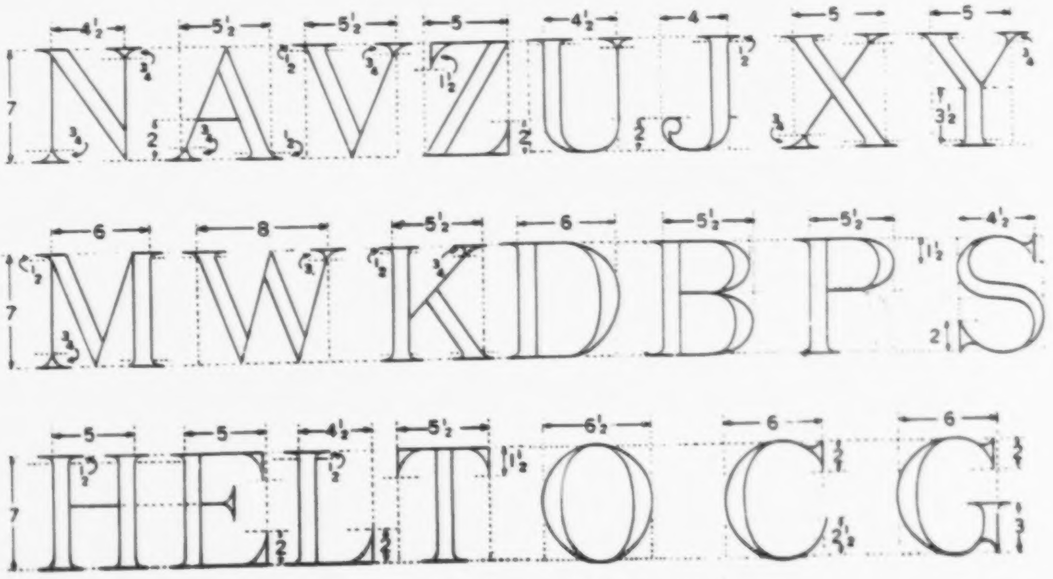


Figure 3-9. Roman capital letters.

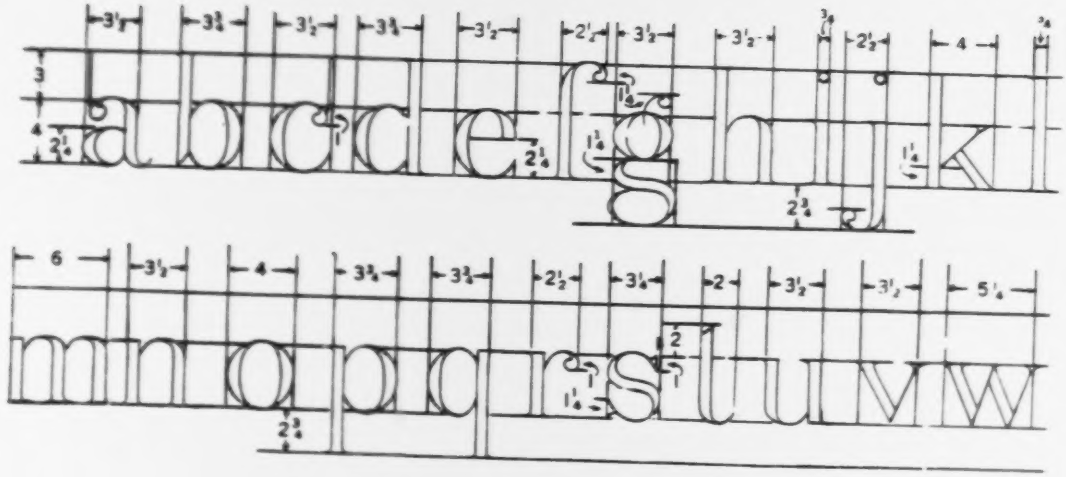


Figure 3-10. Roman lowercase letters.

Proportion. As we said before, there is no standard for the proportions of letter. Some are tall and thin, some are squat and thick, others are light, and still others are heavy. Each style has its own proportion of width to height and its own proportion of thin lines to thick lines. Each type of letter may be used effectively under certain conditions.

Lettering classified as Old Roman is usually 10 times as high as the width of the stems. The thin strokes of these letters are usually half as wide as the thick strokes. The height of the lowercase letters are six-tenths the height of the capitals. These proportions give this lettering a slightly heavy appearance, but one which is quite legible.

In Modern Roman lettering, the width of the stem is wider than the Old Roman style. The capital letters are made 7 units high and the lowercase letters 4. At the same time, the width of the thin strokes of the letters is reduced to a thin line. The contrast between the very thin and the very thick lines of these letters produces lettering that is pleasing in appearance and very legible.

Stability. During our discussion of letter formation, we also discussed stabilizing some letters by constructing their centers slightly off center. The crossbar of the A is placed below center, and the upper parts of the Y connect to the lower stem below center to stabilize these letters. The crossbars of the H, E, and F are placed slightly above center, and the top portions of the P, R, B, X, and S are made smaller than half the letter to give these letters a more stable appearance. The tops of the letters K, X, and Z are made narrower than the bottoms for the same reason.

Uniformity. Perhaps the most important principle of good lettering is the principle of uniformity. As stated in figure 3-11, uniformity in the height, inclination, and spacing is essential for good lettering. We can add to this by including uniform weight of lines as a requirement for good lettering. Now, let us see how these principles are applied.

Height and inclination. The easiest way to insure that the height and inclination of lettering are uniform is to use guidelines. To keep the height of the letters uniform, you should draw light horizontal lines indicating the top and bottom of capital letters. If your lettering includes both capital and lowercase letters, you add another horizontal line indicating the height of the lowercase letters. Figure 3-12 shows you how to use dividers to obtain uniform spacing of these guidelines. After you have determined the height of the lettering and the space between lines of lettering, you set the divider for a span equal to this height and space. Then, starting at the bottom of the first line of lettering, you step off the number of lines desired, as shown on the left side of the vertical line in the figure. Then, using the same setting, you start at the top of the first line of lettering and step off the same number of times as shown on the right side of the vertical line. By drawing horizontal lines through the points established, you obtain the top and bottom guidelines for the height of capital letters. If you want a guideline for lowercase letters, you measure the desired height for these letters on the first line of lettering, and then use the divider as you did before.

If you have many lines of lettering to do, you will find that a lettering instrument, such as the Ames lettering instrument, shown in figure 3-13, is quite useful and timesaving. The top-left section of the figure shows how to use this instrument in conjunction with a T-square to draw properly spaced horizontal guidelines. You insert the point of your pencil

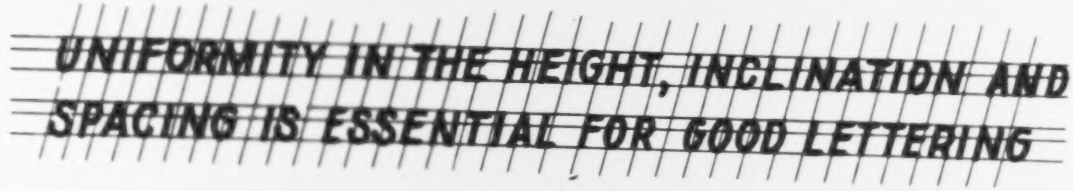

UNIFORMITY IN THE HEIGHT, INCLINATION AND
SPACING IS ESSENTIAL FOR GOOD LETTERING

Figure 3-11. Uniformity.

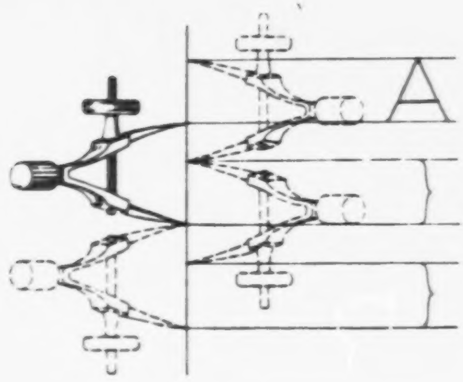


Figure 3-12. Using dividers to space guidelines.

through one of the holes and the instrument slides along the T-square as you move the pencil across the page. The enlarged drawing of the instrument in the lower part of the figure shows the details of how the instrument is used. Notice the three rows of holes in the circular disc of the instrument. The holes in the center row are equally spaced and are used to draw equally spaced guidelines. The two outside rows are used for drawing both capital and lowercase guidelines. The left row gives a proportion of 3 to 5 for lowercase and capital letters, and the right row gives a proportion of 2 to 3.

The design of this particular lettering instrument permits you to use it for lettering ranging in height from 2/32 to 10/32 inch. These various heights are attainable by rotating the circular disc within the outer section of the instrument. The numbers along the bottom edge of the disc are used to set the instrument for a particular letter height. The number aligned with the index on the outer section of the instrument indicates the height of the lettering in thirty-seconds of an inch. In figure 3-13, the number 8 is aligned with the index; therefore, the distance between the capital letter guides produced by this setting is 8/32 inch or 1/4 inch.

By standing the instrument on its greater sloping side, you can use it for drawing guidelines which slope at an angle of 67½° with the horizontal (see the upper-right portion of figure 3-13). Of course, you can always use a triangle and T-square to draw these lines if a lettering instrument is not available. The setup of the triangle and T-square is shown in figure 3-14.

Spacing. It is so important to obtain uniform spacing in lettering that we will discuss the principles of spacing as a separate topic.

Exercises (016):

1. What are the three principles that must be considered in the design of good lettering?

2. Which of the three principles is considered the most important?

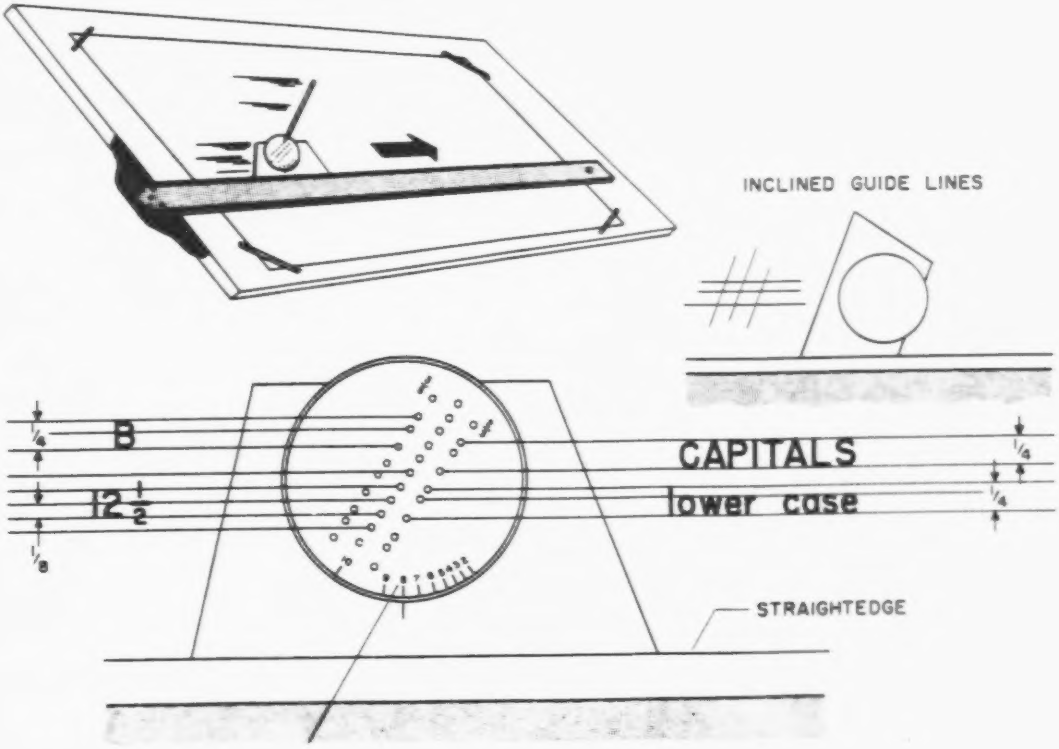


Figure 3-13. Using a lettering instrument.

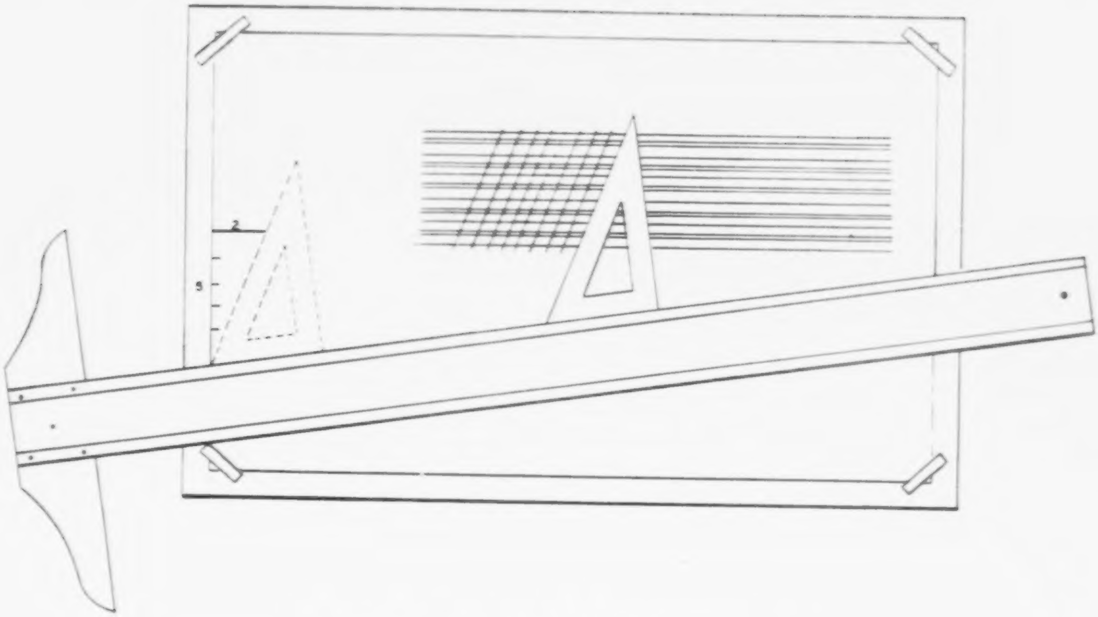


Figure 3-14. Drawing directional guidelines for inclined letters.

3. What is the easiest way to keep the height and inclination of lettering uniform?

4. How does rotating the disc on the lettering instrument affect the letters?

3-4. Principles of Spacing

Since we see things that are close together as a unit rather than single items, the letters making up the text of a page of lettering appear to us as words rather than individual letters. If it were not for the spaces between words, this would not be so. Without these spaces, we would see only lines of lettering which would be almost impossible to read. Improper spacing between letters of words produces a like effect by breaking up words into groups of letters without meaning. Therefore, we can conclude that proper spacing of letters and words does more for the appearance and legibility of a block of lettering than the forms of the letters themselves.

Since the letters of the alphabet vary in shape, the letters in words cannot be spaced at a uniform distance from each other. They are arranged so that the areas of white space (the irregular backgrounds between the letters) are approximately equal. Each letter is spaced with reference to its shape and the shape of the letter preceding it. Adjacent letters with straight sides are spaced farther apart than those with curved sides. Sometimes combinations such as LT or AV may even overlap. Definite rules for spacing are not successful; it is more a matter of judgment and sense of design.

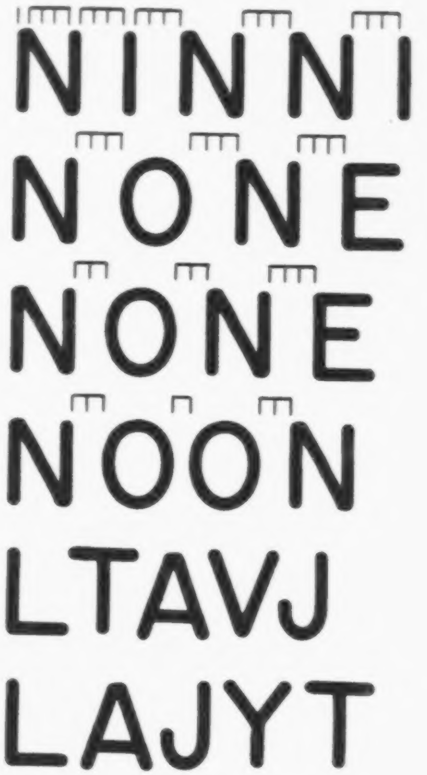


Figure 3-15. Spacing between capital letters.

017. Specify the principles of lettering layout.

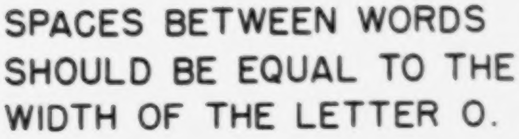

SPACES BETWEEN WORDS
SHOULD BE EQUAL TO THE
WIDTH OF THE LETTER O.

Figure 3-16. Spacing between words.

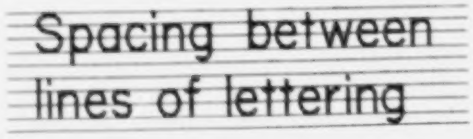


Figure 3-17. Spacing between lines.

Spacing Between Letters. Let us use the lettering in figure 3-15 to go over some of the important details of spacing. Lettering will form words more successfully if the area of spaces between the letters is equal to the area inside the letters. For example, look at the first two lines of figure 3-15. In the top line, after eliminating the area occupied by the diagonal line of the N, we divided the area between any two parallel sides into three equal parts. We used these divisions to arrive at the desired spacing between the N and the I, between the I and the N, etc. Since the spaces between the letters and within the letter appear to be equal to each other, the letters are seen together as one word.

Look what happens in the second line. Notice that the letters are still the same three measured units apart, but because the round letter O does not occupy the full area of a straight-sided letter, the area between the N and O appears much larger than the area between the N and E. When we reduce the distance between the N and O to two units, as shown on the third line, the spaces appear equal. Notice how much better the letters form the word NONE in the third line than they do in the second line. Reducing the distance between two round letters to one measured unit, as shown in the fourth line, produces the same effect.

The spacing of letters that have odd outlines deserves special consideration. When certain of these letters follow one another in a word, obtaining good spacing between them is no problem. The easily spaced combinations are shown in the fifth line of figure 3-15. The design of these letters even permits overlapping to obtain the desired spacing. The combinations shown in the last line of figure 3-15 present a more difficult problem of spacing. In fact, you may have to shorten the horizontal stroke of some letters to obtain good spacing. For instance, the cross stroke of the L and T can be shortened to obtain better spacing between the LA or a YT combinations. As we said before, it is a matter of using good judgment rather than a set rule.

Spacing Between Words. The spacing between words is as important as the spacing between letters of words. There must be enough space to separate letters into words, but the space cannot be so large that it tends to force us to read one word at a time. A good general principle to follow is stated in figure 3-16. Some letterers like to use the letter N for this purpose, and others obtain correct spacing by sketching in a correctly spaced letter I. Using the O is much easier and quicker, since you need to make only a circular movement above the paper next to the last letter of the word.

Naturally, the design of the last letter of a word and of the first letter of the following word must be considered in determining the amount of space you leave between words. You should leave a space equal to a capital O between two full-height, straight-stemmed letters, such as *H* and *E*, or *d* and *b*. Of course, if one or both of the letters are curved, the space should be appropriately reduced. If the two letters involved are lowercase letters, use the lowercase letter o to determine the width of the space. If one lowercase letter is full height and the other lowercase letters are waist high, such as in the words *"bid now"* or *"on him,"* the space would be equal to half a capital O and half a lowercase o.

Spacing Between Lines. The clear distance between lines may vary from 1/2 to 1½ times the height of the letter, but for sake of appearance it should not be exactly the same as the letter height. The lettering instrument provides spacing that is two-thirds of the letter height. As you can see in figure 3-17, this spacing allows room for descenders of lowercase letters and still maintains a clear space of 1/3 letter height between the descenders and capital letters or ascenders of lowercase letters of the following line.

Centering. Since the letters of an alphabet vary in width, it is rather difficult to center a line of lettering in a given area. Ending a line of lettering at a particular point is equally difficult. Figure 3-18 shows one way of solving this problem. First, take a piece of scratch paper and letter the required line. Then, place this line of lettering above the area in which your lettering is to go and center it. Finally, use the sample as a guide to lettering the desired line.

Exercises (017):

1. When lettering, why must you vary the width of the spaces between letters?

2. What, if any, is the difference in the width of the space between the words "send by" and the words "go by"?

3. How many guidelines should you use for each line of lowercase lettering?

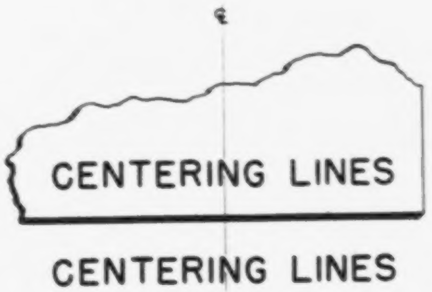


Figure 3-18. Centering a line of lettering.

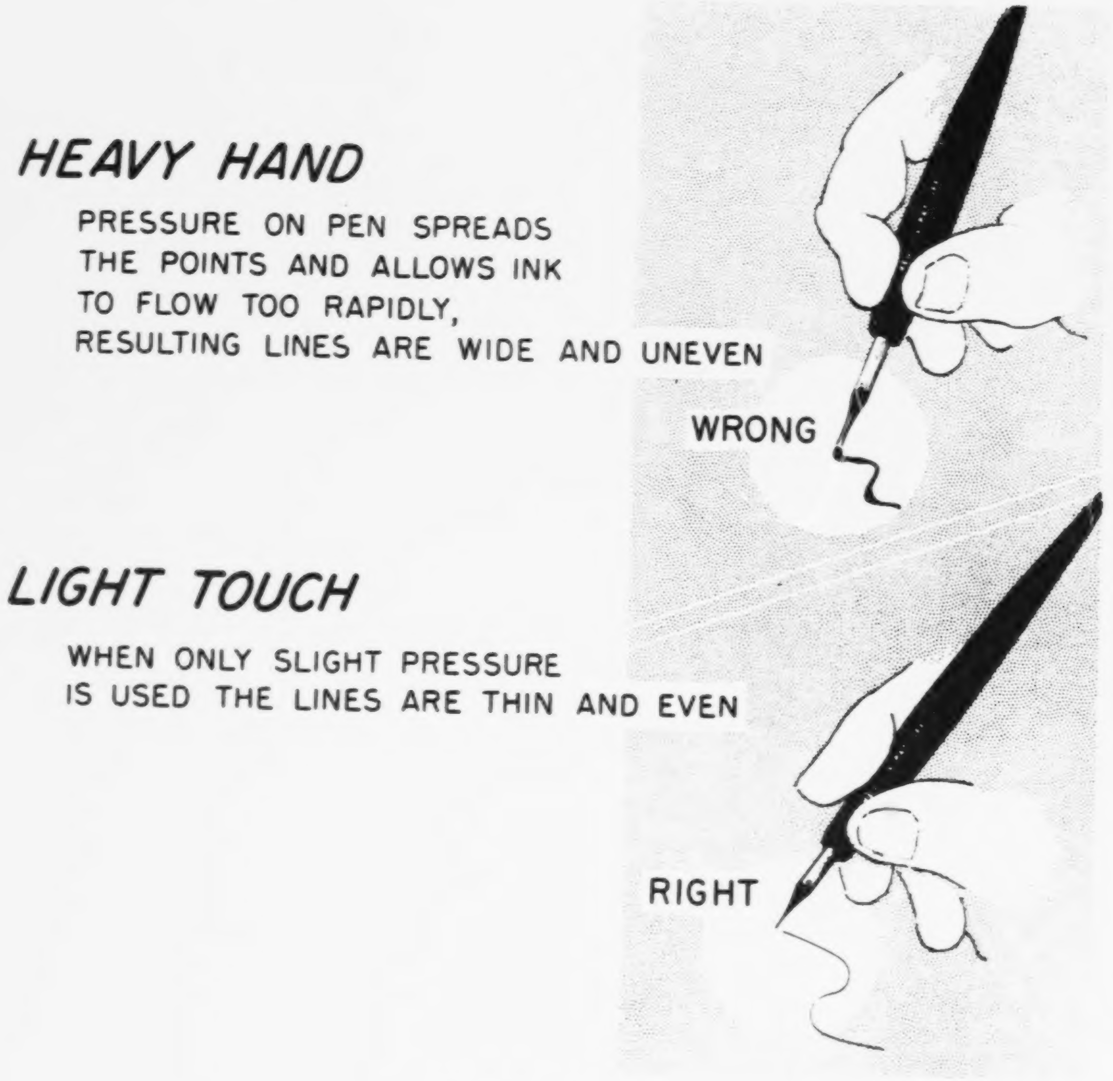

HEAVY HAND
PRESSURE ON PEN SPREADS THE POINTS AND ALLOWS INK TO FLOW TOO RAPIDLY, RESULTING LINES ARE WIDE AND UNEVEN
WRONG
LIGHT TOUCH
WHEN ONLY SLIGHT PRESSURE IS USED THE LINES ARE THIN AND EVEN
RIGHT

Figure 3-19. Using a lettering pen.

3-5. Lettering Tools and Their Uses

As mentioned before, the trend in lettering is toward simplification and speed of production, and the style of lettering is influenced by the tools used to produce it. Therefore, let us discuss some of the tools of lettering and their uses.

018. Cite characteristics of good penciling and of good pencil-holding techniques.

Pencils. Good pencil technique is as essential in lettering as in drawing. The quality of lettering is important, whether it appears on finished work to be reproduced by one of the printing processes or as part of a pencil drawing to be inked. Penciling must be clean, firm, and opaque. The lettering pencil should be selected carefully by trying it out on the paper. In one instance, the same grade of pencil may be chosen as that used for the drawing; in another, a grade or two softer may be preferred. You should sharpen the pencil to a long, conical point and then round the lead slightly on the end so that it is not as sharp as a point used for drawing.

The first requirement in lettering is to hold the pencil or pen correctly and comfortably. Place the thumb, forefinger, and second finger on alternate flat sides and rest the third and fourth fingers on the paper. Draw vertical, slanting, and curved strokes with a steady, even finger movement. Draw horizontal strokes with similar movements, but with some pivoting of the hand at the wrist. Exert pressure that is firm and uniform but not so heavy as to cut grooves in the paper. To keep the point symmetrical, form the habit of rotating the pencil after every few strokes.

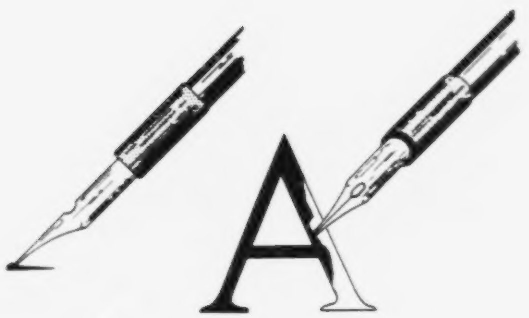


Figure 3-20. Built-up letter.

Exercises (018):

1. Penciling must be ________, ________, and ________.

2. What is the first requirement in lettering?

019. State the characteristics of lettering pens.

Lettering Pens. There are many pens that are made specially for lettering. Lettering pens have points or nibs that

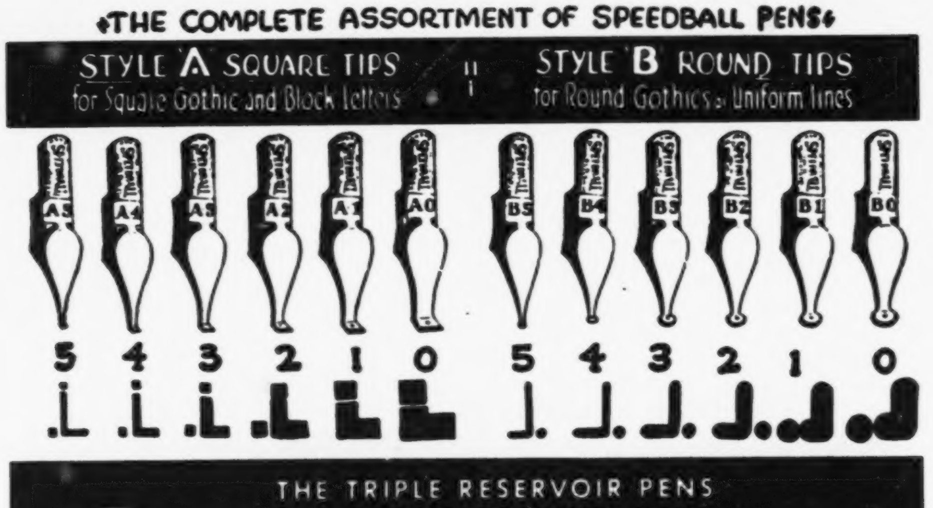

THE COMPLETE ASSORTMENT OF SPEEDBALL PENS
STYLE A SQUARE TIPS
for Square Gothic and Block Letters
STYLE B ROUND TIPS
for Round Gothics & Uniform lines
A5 A4 A3 A2 A1 A0
B5 B4 B3 B2 B1 B0
5 4 3 2 1 0
5 4 3 2 1 0
THE TRIPLE RESERVOIR PENS
for LETTERING DRAWING SIGNS
CALLIGRAPHY CARTOONING
SPEEDBALL PENS
(the only pens with a distributing reservoir over marking tip)
5 4 3 2 1 0
5 4 3 2 1 0
C5 C4 C3 C2 C1 C0
D5 D4 D3 D2 D1 D0
STYLE C OBLONG TIPS
for Roman Text and Shaded Italics
STYLE D OVAL TIPS
for Bold Roman Text & Italics etc

Figure 3-21. Speedball pens.

are different from the points of general purpose pens. The steel nibs of lettering pens are cut in different shapes. The size and shape of the nibs determine the size and style of letters you can make. We will first look at how to use these lettering pens, and then we will discuss the four general types of lettering pens: speedball, text writing pens, technical fountain pens, and felt tip markers.

To use a pen, first set it firmly into a penholder. Many prefer to apply ink to the pen with the quill filler, touching the quill to the underside of the penpoint rather than dipping the pen into the ink bottle. If you dip the pen, you should shake the surplus ink back into the bottle or touch the pen against the neck of the bottle as you withdraw it. Lettering with too much ink on the pen will likely result in blotting or bleeding, especially where two lines meet.

When lettering with a pen, hold the penholder firmly but without pinching (see the bottom illustration of fig. 3-19). Make the strokes of the letters with a steady, even motion and with a slight, uniform pressure on the paper that will not spread the nibs of the pen. Figure 3-19 shows the results of the right and wrong way of using the pen.

A light touch is extremely important when using a common lettering pen to make filled-in or built-up letters. As shown in the right illustration of figure 3-20, the tip of the pen should just barely touch the paper. Actually, it is better if the point is held so that it touches only the ink, because then it cannot pick up fiber from the paper. Here is how you should use the pen for this type of operation. First, apply a good supply of ink to the center of the stem. Then, use the point of the pen to push the ink out to the pencil outline of the letter as you move the pen back and forth through the supply of ink. Work the ink gradually along the entire side of the stem. Then, turn the paper around and work the ink to the other edge. Never try to work the ink toward your hand; always work it away from your hand.

Speedball Pens. These pens (see fig. 3-21) come in a variety of sizes and shapes identified by a letter and number. The nibs of the type A speedball pen form a flat, square writing surface, the strokes made by this type of pen have uniform width and square ends. The nibs of the type B pen form a round writing surface, and the strokes have uniform width and round ends. The nibs of the type C pen, shown in figure 3-22, form a chisel-shaped point which produces thin and thick strokes. Therefore, this type point can be used to make Roman style letters. The D-type speedball pen is similar to the B-type, except that the nibs are oval in shape. The letters produced by D-type pens have thin strokes which are only slightly thinner than the thick strokes.

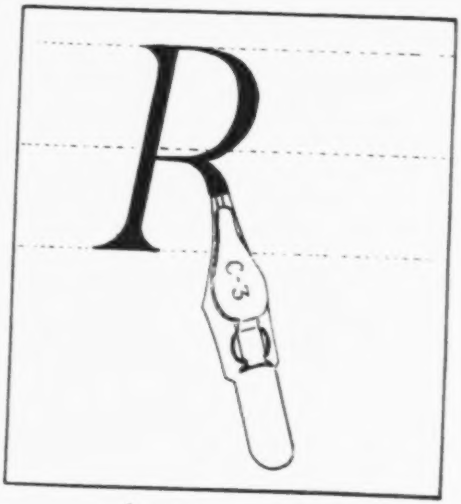


Figure 3-22. Using a speedball pen.

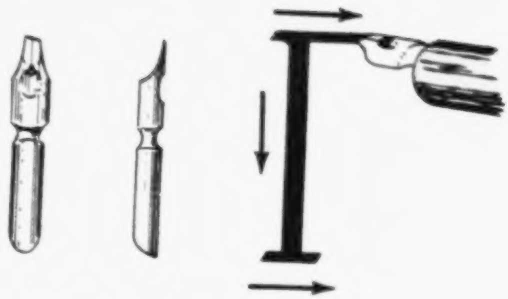


Figure 3-23. Text writer pen.

You probably noticed that speedball pens are equipped with a brass clip that serves as a well for the ink. Use the quill attached to the stopper of the ink bottle to fill the well and keep the outside of the nibs clean. Wipe the pen often with a piece of lintless cloth while you are working, and clean it carefully before you put it away.

Text Writing Pens. Text writing pens are similar to type C speedball pens. They are made of much thinner steel and therefore produce a much sharper stroke. The nibs of the pens are angled so that they touch the paper when the pen is held in a natural writing position (see fig. 3-23).

You will find that both the position of the pen and the working surface are important when using either the text pen or speedball pen. The calligraphers of the Middle Ages worked with an angle of about 60°. At this angle, you see the letters in true size and shape; that is, you do not see them foreshortened. As you can see in figure 3-24, the position of the pen is almost horizontal when the writing surface is slanted 60°. This is important to the proper flow of ink. At

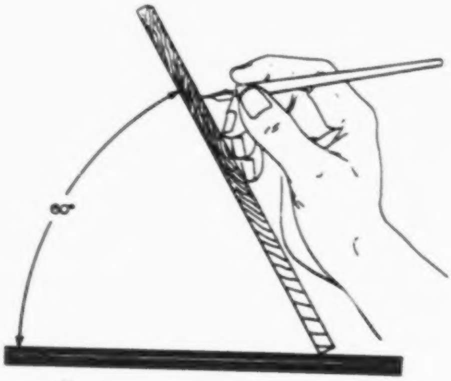


Figure 3-24. Angle of lettering surface and position of lettering pen.

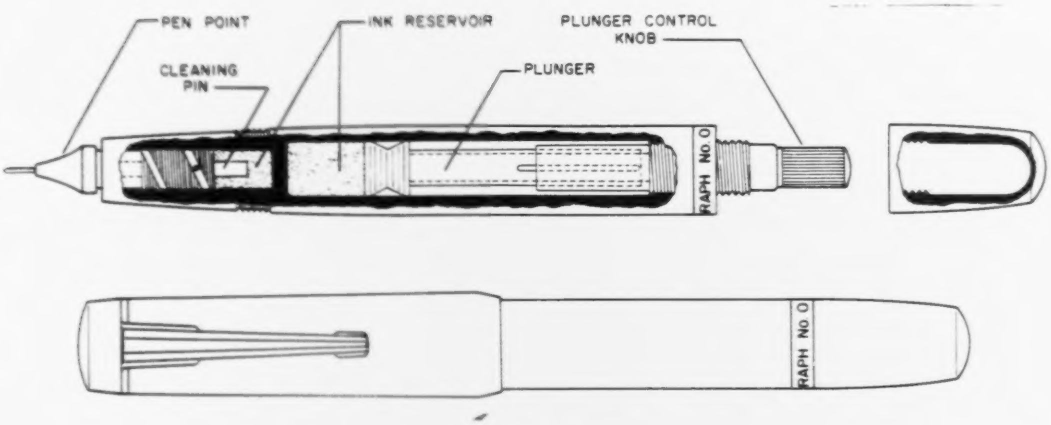


Figure 3-25. Technical fountain pen.

this slight angle, the ink flows smoothly and is not as apt to flow excessively as it would at a steeper angle.

Technical Fountain Pens. Several manufacturers make technical fountain pens. These pens are very convenient for ink lettering and ink drawing. The advantages of these pens over ordinary pens is their great ink holding capacity. We will look at the main parts of the pen: the point assembly, the head assembly, and the ink reservoir (see fig. 3-25).

The point of this pen is specially designed to provide a constant flow of ink when it is in contact with the drawing surface. The point is a hollow tube that has a free floating cleaning pin that runs through the center (you can see a small portion of this protruding through the pen point). When the point of the pen is in contact with the drawing surface, the pin is pushed back. This arrangement allows the ink to flow smoothly through the head assembly and the pen point. The cleaning pin is weighted and will move when the pen is shaken.

The point and cleaning pin are connected to the head assembly. This assembly has inclined grooves with a small hole on its outside surface. These two properties allow the ink to flow from the reservoir to the pen point.

The ink reservoir is simply a plastic barrel that fits snugly over the head assembly and is secured with a lock nut. To fill the reservoir, unscrew the lock nut, remove the reservoir barrel, fill the reservoir, and replace it by reversing the removal steps.

When using a technical fountain pen, you must hold it so that it is perpendicular to the drawing surface at all times. If you don't, the point will wear unevenly and form an elliptical orifice in the pen point. With the point in this condition, you will never be able to draw lines of consistent widths.

Felt Tip Markers. Even though felt tip markers are not truly pens, they are a very valuable lettering tool. They offer a very wide range of color, size, and style possibilities. Felt tip markers are efficient and inexpensive, and in the hands of an experienced illustrator, they can be used to create some striking effects.

Felt tips are made in two styles: refillable and disposable. They consist of a plastic or metal tube that has a cotton wick inside it. The wick extends through the end of the tube and is shaped to form a lettering tip. The wick is then saturated with ink and the tube is then sealed.

There are many advantages for using felt tip markers. These markers are readily attainable through normal supply channels, they are inexpensive, they are maintenance free, and they are disposable. Their main advantage is their versatility. Felt tip markers are very adaptable to all styles of lettering. Their only limiting factor is your own imagination.

The refillable felt tip marker is basically the same as the disposable type. The two types differ in that the one type is nondisposable and has a flow valve that allows the ink to reach the paper. The flow valve on the refillable marker is located internally between the tip and the barrel reservoir. The tip is spring-loaded and is connected to the flow valve. When you depress the tip, the valve opens and lets the ink flow into the tip of the pen. You can control the amount of ink by varying the amount of pressure you apply to the pen tip.

The felt tips are interchangeable on the refillable marker. This gives you the advantage of having many sizes and styles to suit your every need. The only disadvantage of this marker is the time it takes to learn how to control the ink flow. Once you have mastered the techniques of ink flow, the refillable felt tip marker will become a very versatile lettering tool.

Exercises (019):

1. List four pens used for single-stroke lettering.

2. What determines the size and styles of lettering you can make with any given pen?

3. Why is a light touch important when using a common lettering pen?

4. How are text writing pens different from speedball pens?

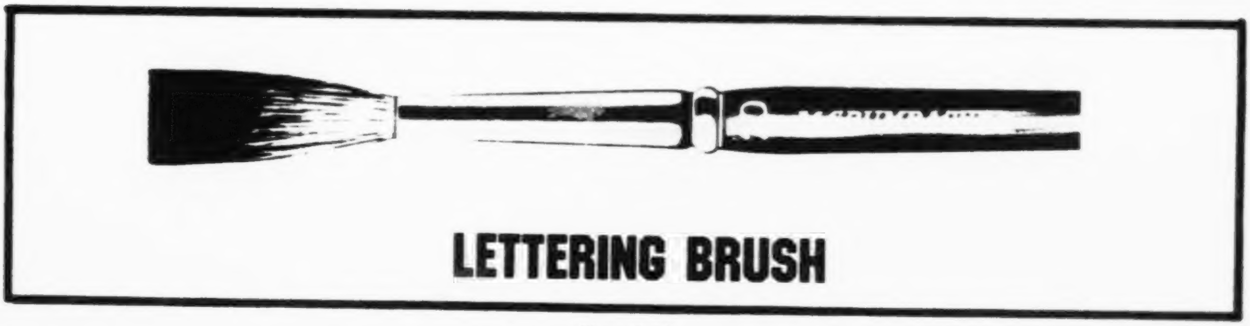


Figure 3-26.

5. What are the three main parts of a technical fountain pen?

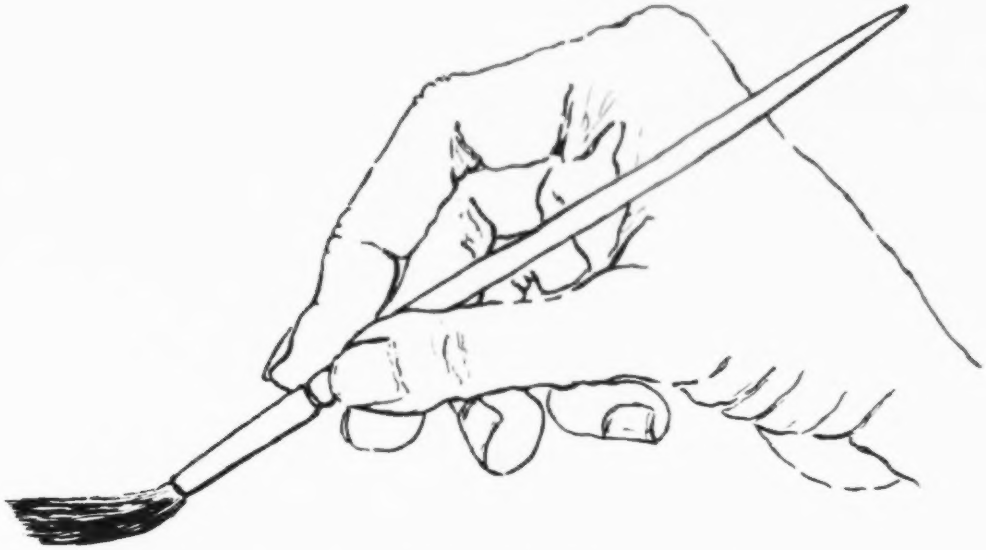
6. What is the main difference between the two types of felt tip marker?

020. Specify the characteristics of lettering brushes.

Lettering Brushes. Lettering brushes, as we have previously discussed, are designed to meet the specific needs associated with brush lettering. The bristles are long and squared off at the ends. The long bristles are used to hold enough paint to complete an even stroke. The length of the bristles also absorb the natural shake of your hand. The squared tips are designed to allow you to start and complete your brushstrokes crisply and neatly (fig. 3-26). It takes practice and dedication to master the task of brush lettering.

The two most important things in brush lettering to begin with are how to load the brush and how to hold it properly. You can't make a proper brushstroke if you don't have enough paint on your brush. To load your brush, you first have to thin your paint to a workable consistency. Place a small dab of paint on a nonabsorbent surface. Drag the bristles of your brush through the paint. As you drag the brush through the paint, roll the handle slightly back and forth between your fingers. This "wiggle" will separate and align the bristles and will load the brush with as much paint as it will hold.

A light grip is all that is necessary when using a brush. (If you grip the brush too tightly, you will have a greater tendency to shake.) Hold the brush between your thumb and forefinger at the ferrule. Holding the brush in this manner will allow you to rotate the brush when you make the round strokes for curved letters. You should also hold the brush with the label (embossed lettering) up so that you can read it. This gives you a point of reference and forces you to keep the bristles aligned the same way each time you use the brush (see fig. 3-27).



PROPER BRUSH HOLDING TECHNIQUE

Figure 3-27.

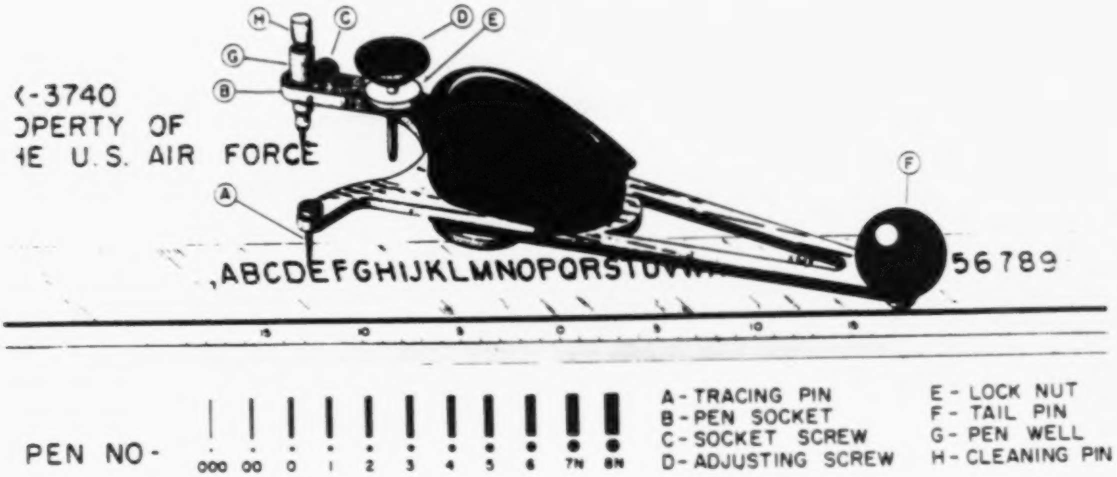


Figure 3-28. Mechanical lettering instrument.

Exercises (020):

1. How do lettering brushes differ in form and function from painting brushes?

2. Why are the bristles in a lettering brush longer than those in painting brushes?

3. Why should you hold your lettering brush with the label up?

3-6. Mechanical Lettering Sets

When freehand lettering techniques are not appropriate for the type of work you are doing, it may be necessary to use one of the four types of mechanical lettering. Because guidelines are not required, uniform and legible lettering can be produced more rapidly than by any freehand method. Mechanical lettering is used principally for drafting title blocks, marginal data for maps and special drawings, charts, graphs, and photographs for reproduction.

There are several brands of mechanical lettering sets on the market today. Some of these go by the names of LeRoy, Letterguide, Varigraph, and Wrico. The operation of these lettering sets is basically the same, so we will focus on the LeRoy type only.

021. Specify the basic components of a mechanical lettering set.

Lettering Set. A standard lettering set consists of a set of templates, a scriber, and a set of pens. A typical setup is shown in figure 3-28. The templates are made of laminated plastic with characters engraved in the face so that their component lines are guide grooves for the scriber. The height of the characters, in thousandths of an inch, is given by a number on the upper righthand side of the template. The range of character heights offered by a standard set of templates is from 80 (0.08 inch, or 5/64 inch) to 500 (0.5 inch, or ½ inch). The scale at the bottom of each template has the zero in the center and is arranged for proper spacing in relation to character heights. The distance between consecutive scale divisions represents the area required by a normal letter.

A standard set of pens for producing various line weights consists of 11 sizes, ranging from 000, the finest, to 8N. Each pen is composed of two parts—the ink reservoir, or pen well, and the cleaning pin (see G and H, fig. 3-28). The reservoir is a series of connected tubes of decreasing diameters, the lowest establishing line thickness. The cleaning pin acts as a valve and protrudes beyond the edge of the bottom tube when the pen is not touching the drawing surface. When the pen is in this position, the ink does not flow. When the pen is rested on a drawing surface, the cleaning pin is pushed up, allowing a flow of ink. Action of the pin in the tube minimizes ink clogging.

The scriber (see fig. 3-28) holds the pen in alignment and controls its motion as the tracing pin (A) is guided through the character grooves of the template, and the tailpin (F) riding in the straight groove of the template. Two types of scribers are available; one is adjustable and the other is fixed. An adjustable scriber produces vertical and inclined letters from a single template; a fixed scriber produces only vertical letters. Except for the locknut, the fixed scriber consists of the same components as the adjustable scriber. These are a tracing pin (A), pen socket (B), socket screw (C), adjusting screw (D), locknut (E), and tailpin (F).

The following table gives the recommended combinations of pens and templates. If a heavier line weight is required, do not use a pen more than two grades above the recommended size:

Template Number	*Pen Number*
80	00
100	00
120	0
140	1
175	2
200	3
240	3
290	4
350	4
425	5
500	6

The rules for freehand letter sizing and spacing apply to mechanical lettering. For blocks having more than one line of lettering, horizontal baselines may be drawn at intervals for the proper spacing between lines.

To center a line of lettering, arrange the letters symmetrically about a vertical centerline. Here is how you do this. First, count the number of letters in the line, add one-half for spaces betweeen words, and subtract one-half for each letter I. Select the template with letters of the desired size and place the zero of its scale on the vertical centerline. Mark the number of divisions equal to half the number of letters in the line, first to the left and then to the right of the zero. This indicates the starting and finishing points.

The procedure for using the mechanical lettering set follows:

a. Loosen the socket screw.

b. Select the appropriate template and the pen recommended for it.

c. Insert the pen in the pen socket so that its shoulder seats up against the scriber arm, and tighten the socket screw.

d. Loosen the adjusting screw locknut and fill the pen reservoir with drawing ink.

e. With the template edge against a T-square, set the scriber tailpin in the straight groove of the template and the scriber tracing pin in the groove of the appropriate character.

f. Using a piece of scrap paper for trial lines, regulate the adjusting screw until the cleaning pin is pushed far enough back to allow the ink to flow freely. If the pin is pushed back level with the end of the tube (that is, if no clearance is provided and the tube is allowed to rest against the drawing surface), ink will not flow smoothly. The amount of clearance varies with the consistency of the ink and the nature of the drawing surface. When trial lines are produced, tighten the adjusting screw locknut.

g. Proceed with the lettering by moving the tracer pin in the desired character groove, but at the same time keep the tailpin in the straight groove. Spacing between letters and words is done by eye and involves the same considerations of equal letter areas as in freehand lettering.

Now let us go over the techniques that you should develop to use the lettering set properly. Hold the T-square in position with the ball of your left hand against the blade. Use the fingers of your left hand to hold the template against the working edge and to change the position of the template when necessary. Hold the scriber between the thumb and first three fingers of your right hand. You can rest your little finger either against the scriber or against the edge of the template.

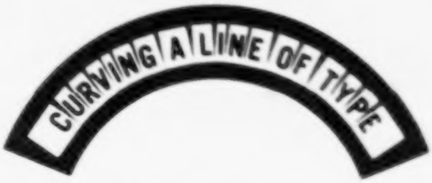

CURVING A LINE OF TYPE

Figure 3-29. Curving a line of lettering.

The following are some important facts to remember when using a lettering pen:

a. Keep the reservoir between 1/4 and 3/4 full; too low an ink level results in irregular lines.

b. When the pen is filled and not in use, place it so that the tip is not in contact with any surface.

c. Before you reuse the pen, twirl the cleaning pin in the tube to loosen any clotted ink.

d. Never use pressure on the scriber if the ink does not flow.

e. Check the adjusting screw setting and the reservoir level.

f. To make fractions, use a template one size smaller than that used for whole numbers.

Maintenance of lettering pens is simple. You should clean the pens with running water and store them in their containers. If water does not clean the pen satisfactorily, use a diluted solution of ammonia. Handle cleaning pins with care because they are fragile and bend easily.

Exercises (021):

1. What are the standard components of a mechanical lettering set?

2. How many pens are there in a set?

3. What is a tailpen?

3-7. Prepared Lettering

For our final discussion on lettering, let's look at some of the mechanically produced handset lettering methods used in the field. These methods include photocomposing machines (both manually operated and computer-generated), pressure sensitive dry transfer lettering, cut-out adhesive-backed lettering, and typewritten copy.

022. Cite two advantages of using prepared lettering.

Lettering Procedure. Prepared lettering can be used as it comes from the press or printing machine by merely cutting it

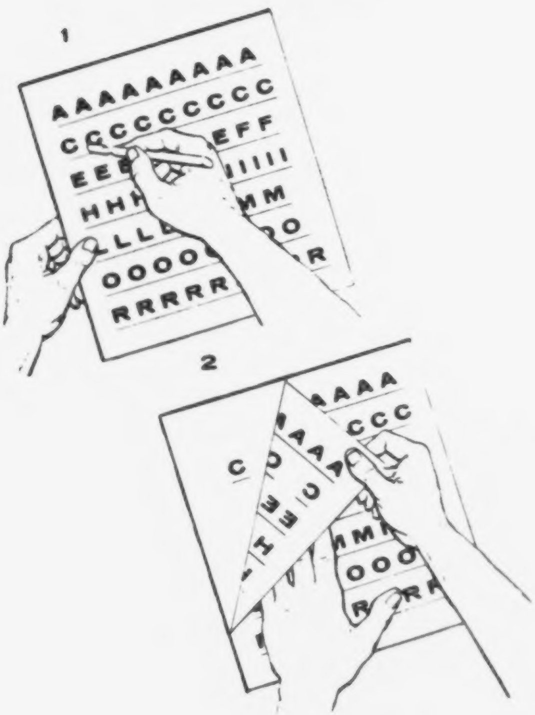


Figure 3-30. Using lettering sheet.

out of the printed page and pasting it in place on your drawing or layout. It can be changed from a straight line of lettering by the method shown in figure 3-29.

The following procedure is used to change a straight line of prepared lettering into a curved line:

a. Draw a curved line where you want the lettering to go.

b. Cut the line of lettering from the page of print, making sure that the cut edges are parallel to the top and bottom edges of the line of lettering.

c. Draw another line parallel to the first line at a distance equal to the distance between the bottom edge of the lettering and the cut edge of the strip. (If the line of lettering is to be curved opposite from that shown in fig. 3-29, this line should be above the first line.)

d. Using a sharp knife or razor blade, make cuts in the strip of lettering between letters. Be careful to leave a small portion of the strip uncut.

e. Apply rubber cement to the back of the strip and to the surface of the paper to which the strip is to be attached.

f. Center the strip on the midpoint of the curve and align the edge of the strip with the curved parallel line.

g. Being careful not to let the strip touch the paper except at the point of alignment (you may have to insert two pieces of tracing paper edge-to-edge between the strip and paper, and peel or slide them back as you go), use the point of an Exacto knife to bend the strip until the bottom edge is aligned along the parallel line. You should start at the center and gradually work toward the ends. As you get each portion of the strip aligned, apply pressure to that portion so that it will adhere to the paper.

h. When you get the strip completely aligned, white around the edges of the strip to eliminate shadows.

Lettering Sheets. When only a few letters or words are needed on a drawing or layout, lettering sheets can be used to great advantage. A large collection of alphabets, numbers, symbols, etc., in various sizes and styles is available under different trade names. These can be applied directly to the finished artwork. The characters are printed on cellophane or acetate sheets with a waxed back and are easily transferred to any smooth surface. You merely position the sheet over the drawing so that the letter to be transferred is correctly positioned, rub the area over the letter, using a glass or plastic burnishing rod, and lift the sheet from the drawing. The letter remains adhered to the paper. This process is shown in figure 3-30.

You must be careful when burnishing a letter that you do not rub over a letter previously transferred. If you do, the letter or part of it will be transferred back to the lettering sheet.

Exercises (022):

1. Cite two advantages of prepared lettering.

2. What is the greatest advantage of transfer lettering sheets?

3. What may happen if you rub over a letter that has already been transferred?

3-8. Photo Composing Machines

Photo composing machines are used to produce type copy that is used on layout or finished artwork to be reproduced. There are two types of photo composing machines in use in the military today: manually operated and computer-generated.

Because there are so many different types of photo composing systems in use, it would be impossible to explain the operating procedures for each system. You should learn to operate the particular machines in your section by studying the operator's manual that is supplied with the machine and by supervised on-the-job training. We will discuss the basic operating principles for both the manually operated and the computer-generated photo composing machines.

The typed copy from photo composing machines is printed on photo-sensitized paper or on film. Paper comes in rolls of 100 and 75 feet, film in rolls of 50 and 35 feet. The 75 feet paper rolls and the 35 feet film rolls both have adhesive backs. The film copy is a positive transparency—black letters on a transparent background. Such copy is ideally suited for silk screen, gravure, and visual aid processes.

023. Specify correct from incorrect procedures for preparing the manually generated composing machine for operation.

Preparation for Operation. The following acceptable steps are used to prepare a typical photo composing machine for operation:

(1) Mix the developer and fixer solutions.
(2) Fill and insert the development tank.
(3) Load the machine with paper or film.
(4) Insert the typemaster.
(5) Set the lighthouse opening.
(6) Set wordspacing dial.
(7) Set letterspacing dial.
(8) Set line position selector knob.
(9) Set front switch.
(10) Set exposurminder.
(11) Set line length dial.

The chemical for the solutions used with the photo composing machine comes in powder form to be dissolved in water according to the instructions printed on the packages. These liquid concentrates are mixed 1 part powder to 3 parts water to form the solutions used in the developing tank. A mark on the tank indicates the level to which you fill the separate compartment with developer, fixer, and water.

To prepare a box of paper for insertion into the machine, loosen the outer bond and pull out the lead strip until the inner bond is broken. Then insert the rounded end of the backup strip, bent tip pointing down, into the paper box slot between the top of the box and the paper, feeding the entire length of the strip into the box until the opposite end hooks over the top edge of the paper box slot.

To insert the paper in the machine, raise the front cover and the lighthouse. Pull out the paper feed clutch knob. Insert the paper into the paper well. Raise the paper roller, as shown in figure 3-31, and feed the paper underneath the first guide, along the paper channel, underneath the second guide, and into the machine. Lower the lighthouse and front cover, leaving the bottom half of the front cover raised.

To insert a typemaster, raise the lighthouse and the front cover slightly. Insert the typemaster as shown in figure 3-32, positioning it so that the drive plate's center locating pin enters the large locating hole in the center of the typemaster.

To set the lighthouse opening, move the lighthouse opening control lever to the setting indicated on the typemaster. Make sure that the lever snaps into position.

The wordspacing dial should be set, using the large numbers on the right side of the dial and turning the wordspacing knob until the number on the dial that corresponds to the point size of the typemaster being used is aligned with the indicator mark. To obtain correct letter spacing, turn the letterspacing knob until zero on the letterspacing dial is aligned with the indicator mark.

The line position selector knob has six setting positions: N, A, B, C, D, and E. The N setting is used for all 1-line typemasters and for the composition of repetitive copy with multiline typemasters. The A and B settings are for top and bottom lines, respectively, on 2-line typemasters. The C, D, and E settings are for top, middle, and bottom lines, respectively, on 3-line typemasters. Correct settings are indicated on all multiline typemasters.

The exposurminder is set by pressing the read button and turning the adjust knob until the meter needle is at 5 on the dial. This setting is normal for all composition.

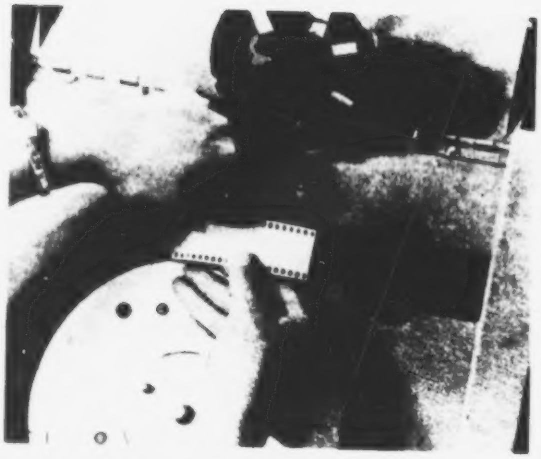


Figure 3-31. Inserting film.

In multiline composition, all lines must start from the same starting point. To assure accuracy of left margins, indentions, and centered lines, zero (starting point) must be brought to the indicator from the left. To make the setting manually, turn the dial to 6; then turn the paper feed knob clockwise until zero is aligned with the indicator hairline.

The following steps are used to compose copy:

(1) Turn the print-space lever to the PRINT position and release it immediately.

(2) Repeat the same procedure for each letter in the word.

(3) Move the print-space lever to the SPACE position for spacing between words.

(4) After composition has been completed, turn the paper feed knob until 7 inches of paper is fed into the machine to advance the last character printed beyond the cutting knife mechanism.

(5) Raise the cutoff and feed lever and hold it up until the red develop light goes on; then release the lever. The developing process will start and is completely automatic.

Exercises (023):

1. Sort out the incorrect from the correct preparatory procedures for operating a typical photo composing machine, then correct the faulty procedures. (Note that these steps are not intended to be put into a sequential order.) List (by letter) the incorrect, then make the corrections.
   a. Mix the developer and fixer solutions using a 1 to 4 ratio of powder to water.

   b. Set the exposurminder by turning the read knob until the meter needle is at 5 on the dial (for normal composition).

   c. Fill and insert the development tank.

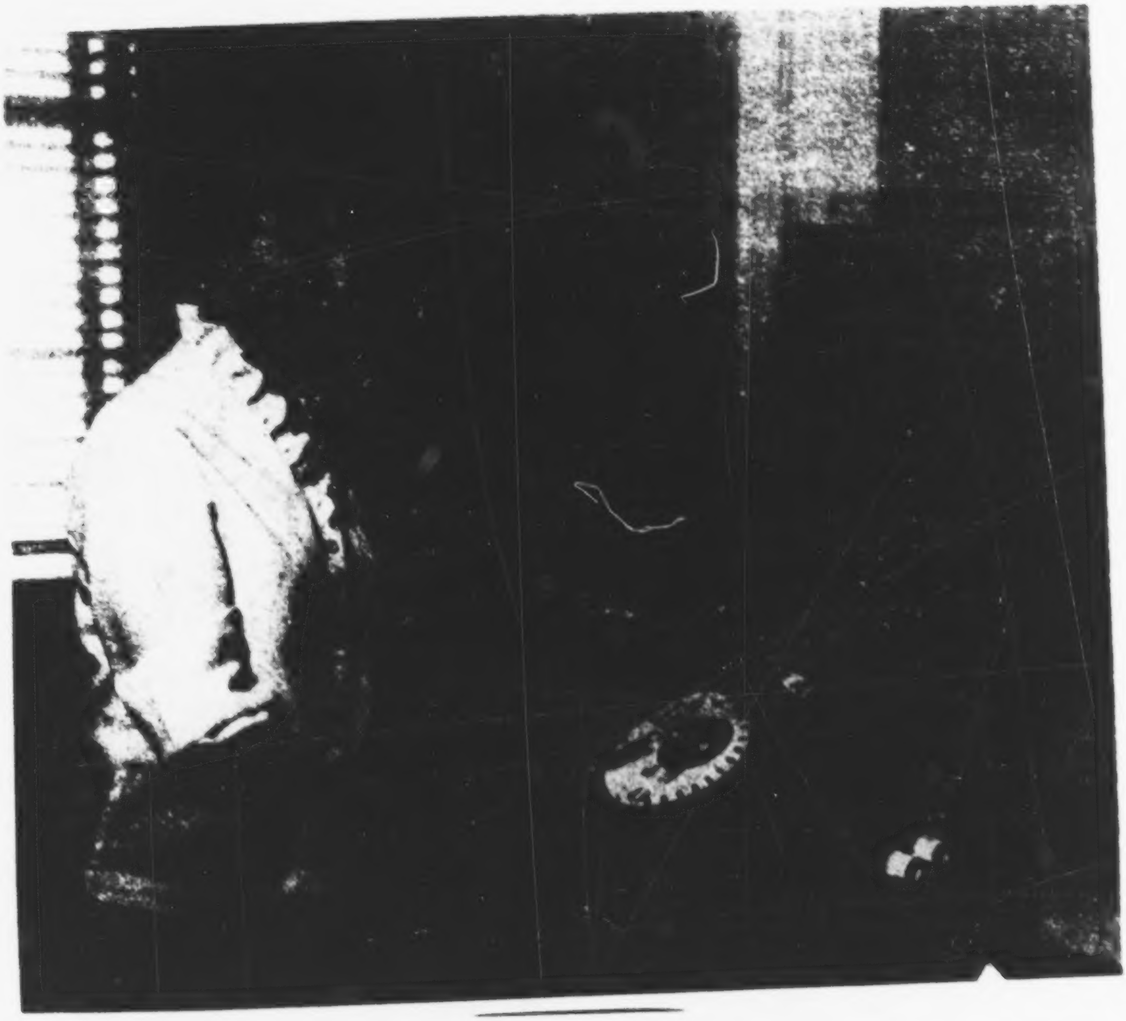


Figure 3-32. Inserting typemaster.

d. To insert paper, loosen outer bond, but do not pull out the lead strip until the inner bond is broken.

e. To insert the typemaster, raise the lighthouse and front cover as much as possible.

f. Set the lighthouse operating control lever to the setting indicated on the letterspacing dial.

g. Set wordspacing dial.

h. Set the wordspacing knob until "1" on the letterspacing dial is aligned with the indicator mark.

i. Set front switch.

j. Set line length dial.

2. Do the same for steps used to compose copy.
   a. Turn the print-space lever to the PRINT position and release it immediately.
   b. Repeat the same procedure for each letter in the word.
   c. Move the print-space lever to the SPACE position for spacing between words.
   d. After composition has been completed, turn the paper feed knob until 7 inches of paper is fed into the machine to advance the last character printed beyond the cutting knife mechanism.

e. Raise the cutoff and feed lever and hold it up until the red develop light goes on; then release the lever. The developing process will now start when you manually initiate it.

024. Specify the characteristics of a computer-generated photo composing system.

Computer-generated Prepared Lettering. A direct keyboard, computer-generated photo typesetter produces a display type composition in sizes ranging from 12 to 120 point. Type styles obtained from film strips or discs have 102 characters in each style. A standard film strip consists of two duplexed type faces. You can use two film strips at any one time; thus you have four type faces at your disposal. A standard disc contains four type faces on one disc.

The secretarial keyboard is used to program the text into electrical impulse signals. A display screen allows you to visually check your copy before printing. You can correct, edit, or justify your copy at this time. (Editing and justification capabilities depend upon the make and model of your particular system.)

A lens turret selects the type size. The style size ranges from 12 to 120 point. The 96 and 120 point type is limited to uppercase characters only. The typewriter console also has function controls for changing type styles, kerning, lettering spacing, and automatic advancement of the photographic materials.

The characters are photographed through the film strip or disc with an instantaneous flash of light. The light passing through the lens system exposes the character image on the photographic material. As the characters are exposed, the photographic material is automatically advanced and stored in a light-proof receiving cartridge. The photographic material consists of standard Ektamatic or Durographic paper or film. The material is available in either 35mm or 8" rolls, depending upon which system your unit uses.

After exposure, the typeset copy on the photographic material is developed through an automatic processor. The cassette containing the exposed film/paper is removed from the typesetting unit and is inserted into the processor. The processor removes the film/paper from the cassette and moves it through the three stage developing process (developer, fixer, and rinse). After developing and drying, the film/paper is ready for use.

There are many different computer-generated photo typesetting systems in the field. These systems are similar, but each does have its own different characteristics. It would be confusing, if not impossible, to address all of these systems individually. You should study the operator's manual to completely familiarize yourself with your particular system.

Exercises (024):

1. What are the two major components of a computer-generated photo composing system?

2. Is it possible to edit and justify your copy?

3. If editing and justification can be done, when are they done?

025. Describe the functions and uses of a waxer.

Waxers. There are some projects that require you to adhere copy or photos to art surfaces. You will often have to place copy on layouts or headliners on wall charts. You can use a wide variety of cements, aerosol sprays, or glues to do this. The most convenient method, however, is the waxer.

A waxer (either the table model or the hand-held model) applies a thin coating of wax to the back side of your copy. The wax used is specially made to be sticky. The coating of wax will allow you to attach your copy to your working surface and to reposition it as necessary. The ability to move your work without damaging it is the greatest single advantage of using a waxer.

Operation. Waxers are simple to operate. On table models, you feed your materials, face up, between the rollers. The top roller is a feed roller which pulls your material over the bottom roller. The bottom roller is partially submerged in a dish of melted wax. As the roller turns, it picks up melted wax and places a thin coating on your material.

Hand-held models use no feed mechanism. The roller is attached to a hand-held heating unit. This has a small reservoir where the wax is melted and stored. Wax is deposited on your material by rolling the unit across the back of your material.

The max used in these machines is available in blocks or sticks. The wax is placed in the heated reservoirs to melt. The temperature is adjustable, but you should take care to keep the wax from becoming too hot. If the wax gets too hot, it will bleed through your work. On the other hand, if the wax is too cold, it will not flow properly and will place unnecessary wear on your machine. For safety reasons, always turn the waxer off before you leave at night.

Exercises (025):

1. What is the main purpose of a waxer?

2. Describe the two types of waxers.

3. What is the main advantage of using a waxer?

4. Why should you keep the wax from getting too hot or too cold?

CHAPTER 4

Geometric and Graphic Construction

DRAWING PROBLEMS encountered by the graphics specialist can usually be solved in several different ways. For instance, in ordinary drawing practice, the graphics specialist would use a T-square and a triangle to draw a line perpendicular to a given line, arc, or what have you, or locate a point of tangency on a circle by estimating its position. When extreme accuracy is of first importance, the task should be accomplished by geometric construction. Also, when making a drawing of an unusually large size—such as full-size sheet-metal patterns—the geometric principles should be used.

Actually, you apply the principles of geometry whenever you use your drawing tools. Therefore, increased knowledge of these principles, coupled with skills acquired in using your drawing instruments, prepares you to do more difficult jobs in the future. For now, let's concern ourselves with procedures, and not with mathematical proof of geometric construction.

4-1. Terms and Principles

Perhaps the material in this section may be a review for you, perhaps not. In any case, you need to know the more common definitions of terms and principles. Let's begin with lists of definitions of terms and basic principles, and then follow with a discussion of important facts which, in many cases, is a combination of the two. The lists which follow will serve as a quick reference during your studies.

026. Define the terms and explain the basic principles of geometric construction.

Definitions of Terms. As you study these definitions, refer to figure 4-1.

Angle—The figure formed by the coming together of two lines at a point.

Arc—A curve which is not closed.

Chord—A straight line intersecting a curve.

Circle—A closed curve all points of which are equidistant from a point called the center.

Concentric circles—Circles having the same center.

Diameter—The length of a straight line through the center of an object.

Eccentric circles—Circles not having the same center point.

Ellipse—A plane curve, the path of a point the sum of whose distances from the foci (two fixed points) is constant; a conic section, the closed intersection of a plane with a right circular cone.

Helix—The curve formed on any cylinder by a straight line in a plane that is wrapped around the cylinder, such as an ordinary screw thread.

Heptagon—A polygon of seven angles and seven sides.

Hexagon—A polygon of six angles and six sides.

Hyperbola—A curve formed by a section of a right circular cone when the cutting plane makes a greater angle with the base than the side of the cone makes. Also, a hyperbola may be produced by a point moving so that the difference of its distances from the foci (two fixed points) is constant and equal to the transverse axis of the hyperbola.

Nonagon—A polygon having nine angles and nine sides.

Octagon—A polygon having eight angles and eight sides.

Parabola—A conic section formed by the intersection of a cone with a plane parallel to its side.

Parallelogram—A quadrilateral whose opposite sides are parallel.

Pentagon—A polygon having five angles and five sides.

Plane—A two-dimensional flat surface.

Plane figure—A surface or space completely inclosed by lines.

Polygon—Any plane figure completely inclosed by straight lines. When a polygon has equal sides and equal angles, it can be inscribed within or circumscribed around a circle. In this case, it is known as a regular polygon. (In common practice, the term "polygon" usually implies that a figure has five or more sides.)

Quadrilateral—A plane figure bounded by four straight sides.

Radius—A straight line extending from the center of a circle or sphere to the curve or surface.

Sector of a circle—The figure bounded by two radii (an angle) and the included arc of a circle, ellipse, or other central curve.

Segment of a circular area—That part which is bounded by a chord and an arc.

Trapezoid—A quadrilateral with two sides parallel.

Trapezium—A quadrilateral with no sides parallel.

Triangle—A plane figure bounded by three straight sides, and the sum of the interior angles is always 180°.

Some Principles of Plane Geometry. Any one or all of these principles may apply to a particular drawing.

(1) A straight line is the shortest distance between two points.

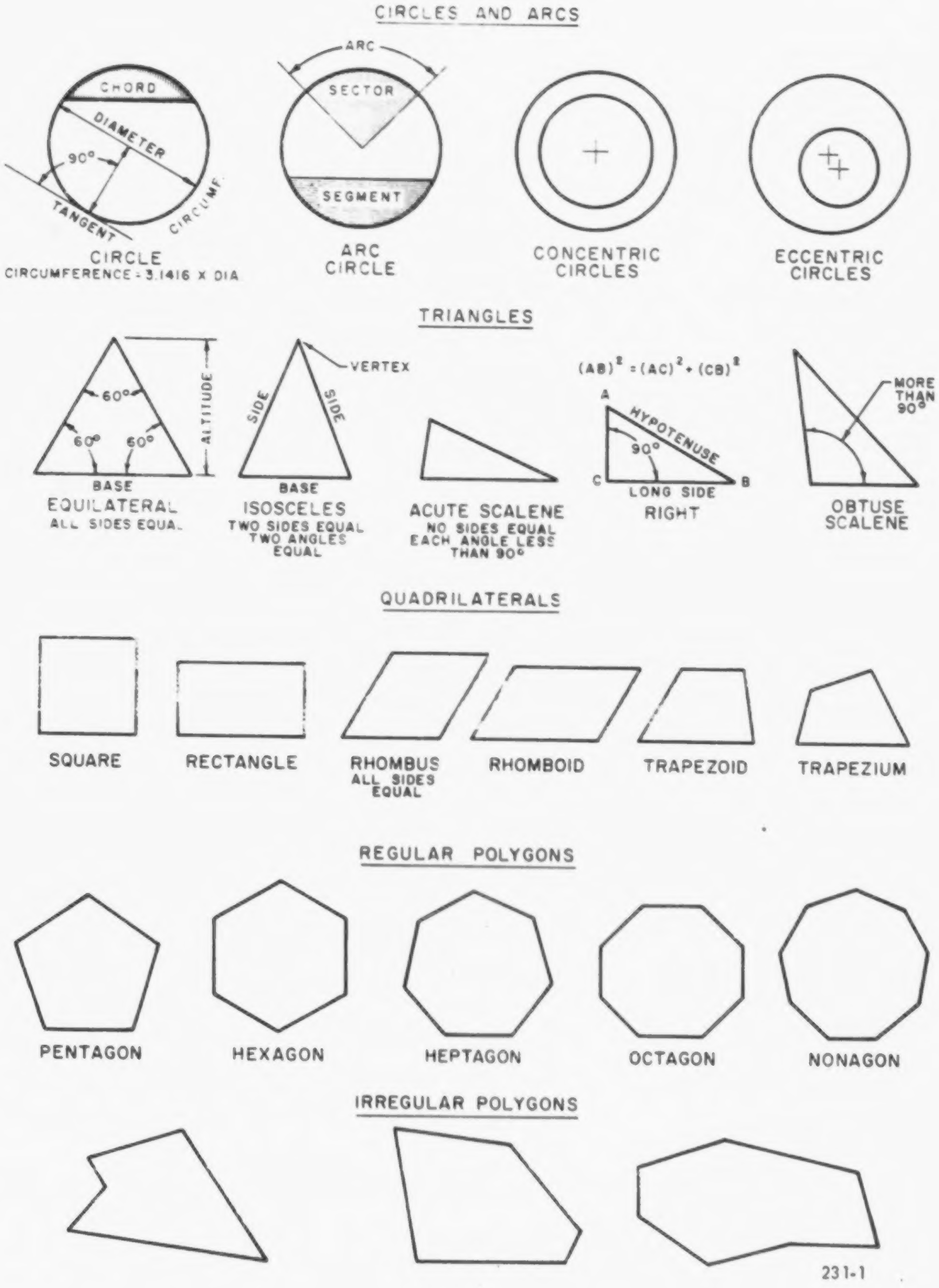

CIRCLES AND ARCS
CHORD
DIAMETER
90°
TANGENT
CIRCUMF.
CIRCLE
CIRCUMFERENCE = 3.1416 X DIA
ARC
SECTOR
SEGMENT
ARC
CIRCLE
CONCENTRIC
CIRCLES
ECCENTRIC
CIRCLES
TRIANGLES
60°
60°
60°
ALTITUDE
BASE
EQUILATERAL
ALL SIDES EQUAL
VERTEX
SIDE
SIDE
BASE
ISOSCELES
TWO SIDES EQUAL
TWO ANGLES
EQUAL
ACUTE SCALENE
NO SIDES EQUAL
EACH ANGLE LESS
THAN 90°
(AB)² = (AC)² + (CB)²
A
HYPOTENUSE
90°
C
B
LONG SIDE
RIGHT
MORE
THAN
90°
OBTUSE
SCALENE
QUADRILATERALS
SQUARE
RECTANGLE
RHOMBUS
ALL SIDES
EQUAL
RHOMBOID
TRAPEZOID
TRAPEZIUM
REGULAR POLYGONS
PENTAGON
HEXAGON
HEPTAGON
OCTAGON
NONAGON
IRREGULAR POLYGONS
231-1

Figure 4-1. Geometric figures.

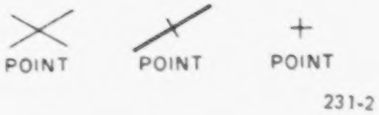


Figure 4-2. Points.

(2) A point represents a specific location; it has no dimensions.

(3) Two lines are perpendicular when the angle formed at their intersection is 90°.

(4) When measuring the distance between a point and a line, measure along a perpendicular from the point to the line.

(5) Parallel lines are equidistant from each other at all points.

(6) Curves are tangent to straight lines or to other curves at only one point.

(7) Regular polygons have all sides and angles equal.

(8) A line intersected by equally spaced parallel lines is cut into equal segments.

(9) Any figure may be moved from one place to another without altering its size or shape.

(10) From a given point on a given line, only one perpendicular can be drawn.

(11) The diagonals of a parallelogram bisect each other.

(12) Through three points not in a straight line, only one circle can be drawn.

(13) When two circles are tangent to each other, the straight line joining their centers passes through the point of tangency.

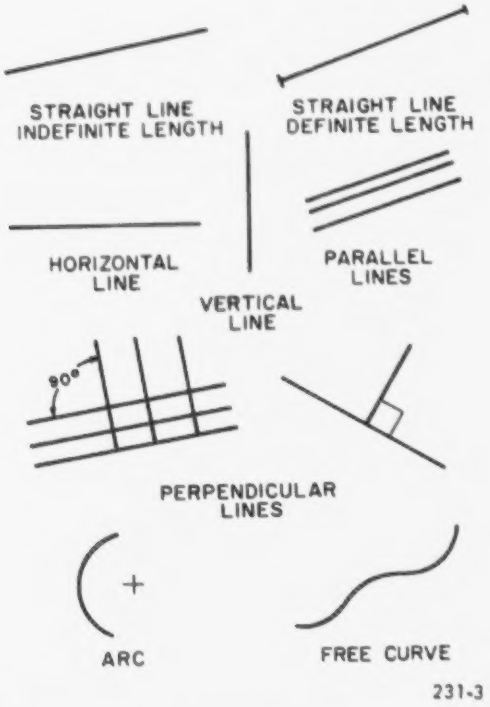


Figure 4-3. Lines.

(14) The major and minor axes of an ellipse divide the figure into four equal parts.

Exercises (026):

1. A straight line intersecting a curve is called a ________.
2. What represents a specific location, but has no dimensions?
3. Is question 2 a definition of a term or a principle of plane geometry?

027. Identify the geometric figure or figures on a flat surface that are generated by movement.

Points, Lines, and Planes. The branch of geometry that we are concerned with is called plane geometry. It derives its name from the fact that it deals with the position of points and lines on flat surfaces, which are called planes.

Point. A point is a position representing a location in space or a flat surface; it has no height, width, or depth. Figure 4-2 shows three ways to represent a point. Notice, as illustrated, that a point may be represented by the intersection of two lines, by a small crossbar on the line, or by a small cross. A point is never represented by a simple dot on the paper.

Line. A line is an imaginery geometric figure. A line does not exist in nature; it is generated by a point in motion. It has length but not thickness. (Dots, lines, and points in drawings have thickness merely as a convenient way to represent small areas or planes (see fig. 4-3.)

- A line that has the same direction for its entire length is a *straight* line.
- A line that changes in direction along its length is a *curved* line.

Plane. A plane or flat surface is generated by a straight line moving in a direction other than that of its length, creating an area or surface with length and breadth, but no thickness.

Exercises (027):

1. Under the concepts of geometry, how is a straight line produced?
2. How is a curved line produced?
3. What is a plane?

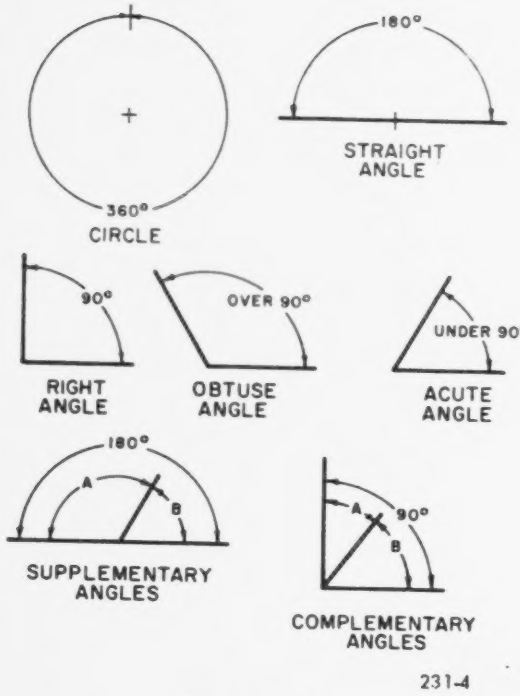


Figure 4-4. Angles.

028. Given definitions of types of angles, match each with a class or group and illustrate.

Angles. An angle is formed by two lines meeting at a point. The lines are the sides of the angle, and the point at which they meet is the vertex. Angles are divided into five general classes and two general groups. The classes are:

(1) An angle formed by perpendicular lines with one angle at 90° is a right angle.

(2) An angle that is less than a right angle, or 90°, is an acute angle.

(3) An angle that is greater than a right angle but less than a straight angle is an obtuse angle.

(4) An angle whose sides extend in opposite directions from the vertex, or 180°, is a straight angle.

(5) An angle that is greater than a straight angle but less than 360° is a reflex angle.

The two general groups are: (1) right and straight angles and (2) oblique angles. Since there are only two groups, you can define one in relation to the other—oblique angles are all angles other than straight or right angles.

Adjacent angles. Angles which have a common vertex and side are adjacent angles. They can be supplementary or complementary angles, as shown in figure 4-4.

Triangles. A triangle is a plane figure bound by three straight sides, and the sum of the interior angles always totals 180°.

Exercises (028):

1. Two angles with a common side and vertex are called ________ ________.

2. Match the terms in column A with the definition in column B by writing the correct letter in the blank provided.

Column A

(1) Obtuse ________
(2) Right ________
(3) Reflex ________
(4) Oblique ________
(5) Straight ________
(6) Acute ________

Column B

a. Angles other than straight and right angles
b. An angle that is less than a right angle
c. An angle that is greater than a right angle but less than a straight angle
d. An angle formed by perpendicular lines
e. Angles with a common vertex
f. An angle that is greater than a straight angle but less than two straight angles
g. An angle whose sides extend in the opposite direction from the vertex

3. Draw and identify each of the following angles.

a. Acute and oblique.

b. Right.

c. Obtuse and oblique.

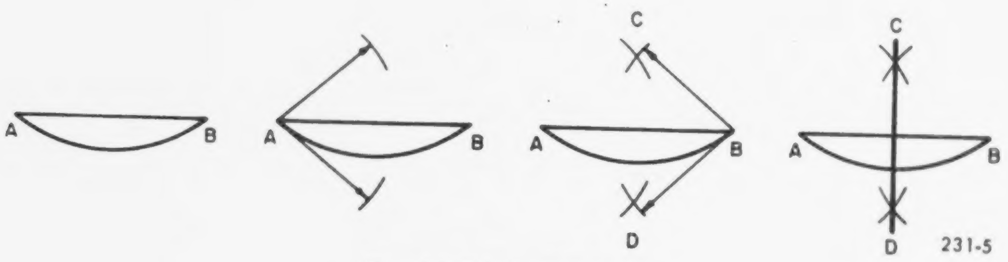


Figure 4-5. Bisecting an arc or a line.

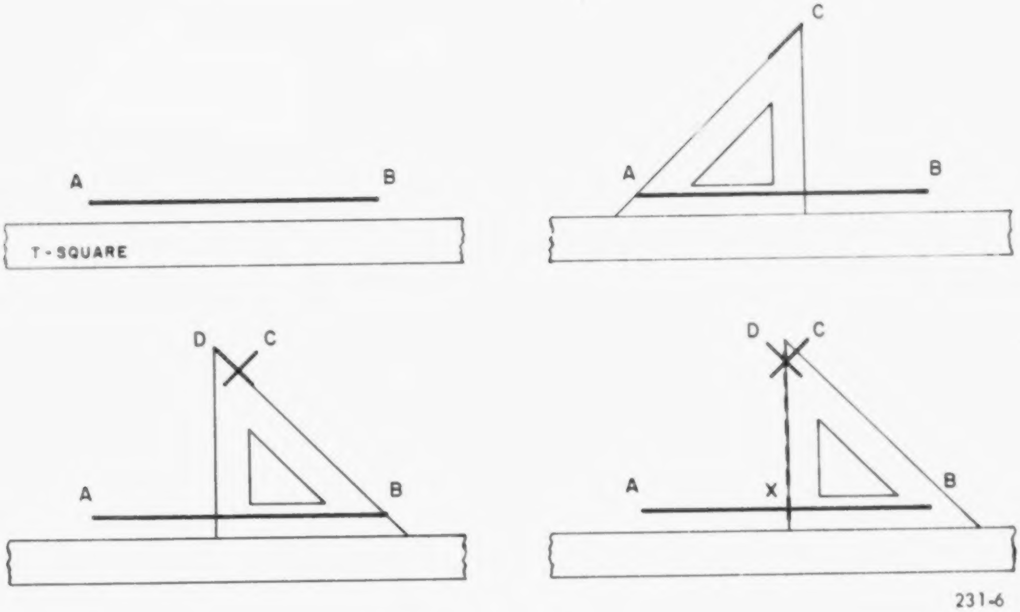


Figure 4-6. Bisecting a line with T-square and triangle.

d. Straight.

e. Reflex and oblique.

4-2. Bisecting Figures and Constructing Perpendicular Lines

Bisecting figures and constructing perpendicular lines are just as basic to drafting as addition is to arithmetic. These are simple and may be drawn by several methods. Whatever method you use, the accuracy depends on you. Now is the time to start practicing accurate drawing as you study the following procedures.

029. Given a line or an arc, bisect and construct lines perpendicular to each and identify the method used.

Bisecting an Arc or a Line. An arc or a line may be bisected by use of either a compass or triangles. The geometric (compass) method is by far the more accurate. Given line or arc AB, as shown in figure 4-5, use the following procedures:

(1) Set the compass for any radius greater than one-half of AB.

(2) Using A and B as centers, draw two arcs to intersect at points C and D, as shown in figure 4-5.

(3) The point at which line CD crosses AB is the center, and also line CD is perpendicular to line and arc AB.

Bisecting a line or an arc with a T-square and 45° triangle is not the most accurate method, but it is the fastest. If the given line or arc is a long line or large arc, this method is unusable. Here is the procedure for bisecting a line or an arc, as shown in figure 4-6.

(1) Place the 45° triangle on the T-square so that the hypotenuse of the triangle passes through point A; draw line AC.

(2) Turn the triangle over and repeat the operation, using point B. Draw line BD.

(3) Place the vertical edge of the triangle at the intersection of AC and BD, and draw the vertical line which bisects line AB at point X.

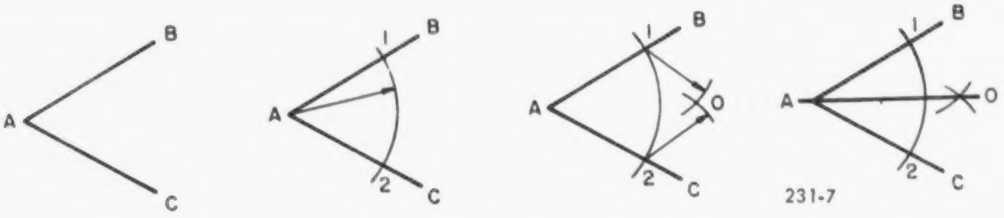


Figure 4-7. Bisecting an angle.

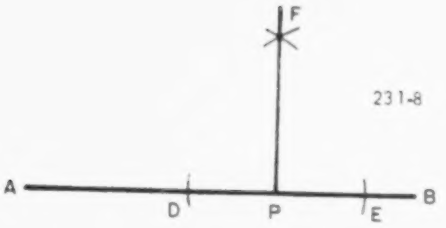


Figure 4-8. Constructing perpendiculars.

Bisecting an Angle. Given angle BAC, use the following procedures:

(1) With A as the vertex or center, set the compass at any radius, and draw an arc cutting lines AB and AC at points 1 and 2.

(2) Set the compass at a radius greater than one-half of points 1 and 2.

(3) With 1 and 2 as centers, draw two arcs to intersect at 0.

(4) Draw line A0 to bisect the angle (see fig. 4-7).

Construction of Perpendiculars. Constructing perpendicular lines follows the same procedure as bisecting a line, arc, or angle, except that a perpendicular may be constructed to a point, or from a point. When constructing a perpendicular to a given point on a line, using P as the point on line AB, as shown in figure 4-8, use any practical radius and strike an arc that intersects line AB at points D and E. Using points D and E as centers, strike the arc to intersect at some point F. Draw a straight line through points F and P. This line is perpendicular to line AB.

Exercises (029):

1. Bisect a line $2\frac{7}{32}''$ long drawn at an angle of 33°.

2. Draw a line perpendicular to a given arc at 241° with a radius of 2".

4-3. Construction of Linear Figures and Division of Figures into Equal Parts

This segment first presents several methods of drawing parallel lines and then the procedures to divide lines and spaces into any number of equal parts. This is one of the procedures that will be used throughout your illustrating career. Of course, lines can be drawn parallel by using a T-square and triangle. However, when the demand is for accuracy or the drawing is very large, such as banners, large posters, etc., the T-square and triangle should not be used for drawing parallel lines.

030. Given a line through a point, draw another line parallel.

Given a Line. Given line AB and the required point C, as shown in figure 4-9:

(1) With C as the center and any convenient radius, strike an arc DE to intersect line AB at point F.

(2) With F as the center using the same radius, draw an arc GH to intersect line AB at K.

(3) With CK as a radius and F as the center, strike an arc intersecting arc DE at L.

(4) Through points L and C draw the required parallel line.

This problem can also be drawn by the triangle method using the following procedure (see fig. 4-10).

Place the hypotenuse of a triangle on the given line AB with the base on the triangle resting against the T-square.

Hold the T-square in position and slide the triangle to point C and draw line CD.

To draw a line parallel to another line at a given distance is like drawing perpendiculars to a point on a line. You can do most of the straight line by either geometric construction or the triangle method (see fig. 4-11), but the curved lines can be done only by geometric construction, as shown in figure 4-12.

Exercises (030):

1. Given a line 2½ inches long, draw another line parallel 3/4 of an inch away.

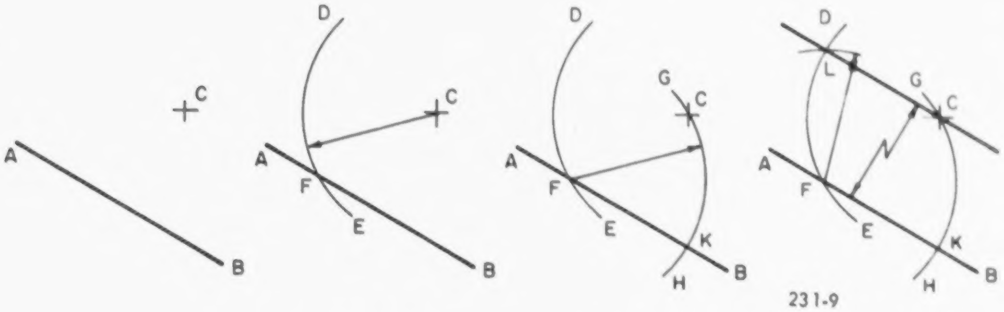


Figure 4-9. Drawing lines parallel to a given point.

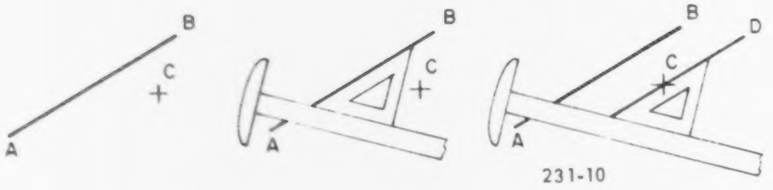


Figure 4-10. Drawing lines parallel using T-square and triangle.

2. Given a curved line 2½ inches long, draw a parallel line 5/8 of an inch away.

031. Given a line and a space, divide each into equal parts.

Given a Line or Space. Assume that a given line is to be divided into equal parts.

(1) Draw line AB which is to be divided.

(2) From point A, draw a line any length at any convenient angle.

(3) From point A, lay off the number of equal parts with either a scale or a pair of dividers on line AC.

(4) From the termination point of the last space on line AC, draw a line connecting the last point with point B.

(5) With the edge of the triangle set parallel with the last point on line AC and point B, draw lines from the points on line AC to line AB (see fig. 4-13).

Dividing spaces into equal parts employs the same method as the draftsman's method for dividing a line with a scale. The one difference is as shown in figure 4-14. To divide spaces, the scale is placed at a convenient angle covering the number of equal spaces needed, whereas in the division of a line with a scale, the scale is placed so that zero coincides with the end of the line A and the last point on line AC falls on the line BC, and line BC can be any length.

Exercises (031):

1. Given a line 3⅝ inches long, divide it into six equal parts, using the geometric construction method.

2. Use the scale method to divide a space into equal parts.

4-4. Construction of Lines Tangent to Circles and Arcs, and Rectifying Arcs

Often, as a graphics specialist, you will be required to construct lines tangent to circular arcs. A circular arc is a portion of the circumference of a circle. Accurately drawing straightline tangents to circles or arcs is difficult, because there are elements of optical illusion involved. Therefore, you must know how to construct tangents by several methods.

A tangent to a circle may be drawn either to a point on the circle or to a point not on the circle. You will also be required to draw a straight line which is approximately equal in length to the length of an arc. This is known as rectifying an arc. But first we shall cover lines of tangency, then methods of rectifying an arc.

Construction of lines tangent to a point on a circle, circular arc, or curves will be the principle drawing exercises of this section. Study each figure carefully; then practice making the construction.

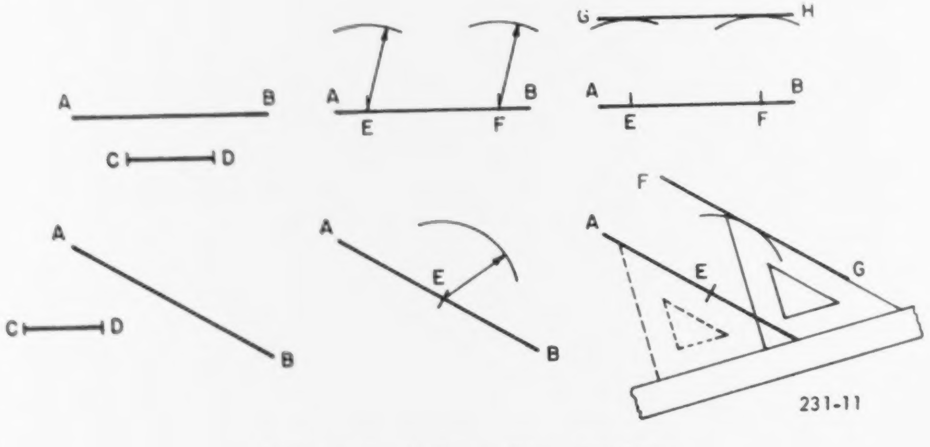


Figure 4-11. Drawing lines parallel at a given distance.

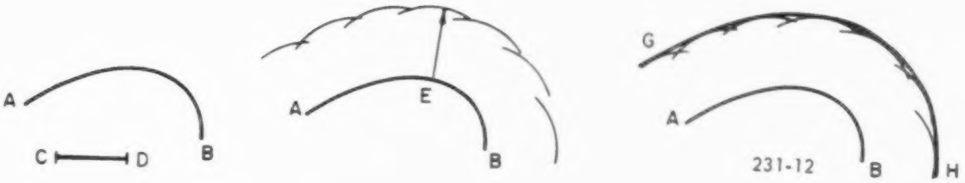


Figure 4-12. Drawing curved lines parallel at a given distance.

032. Given a point on a circle, construct a line tangent to that point.

Constructing a Line Tangent to a Point. Figure illustrates the procedure to construct a line tangent to a circle at point S.

(1) Given point S on the circle with 0 as the center, set the compass to a radius equal to SO; with S as the center, strike arc OD to cut the circle at O and E.

(2) With E as a center, using the same radius, draw an arc to cut OD at X.

(3) With X and E as centers and any convenient radius greater than SO, strike an arc. From this point draw a line tangent to the circle at point S.

Figure 4-16 demonstrates the same procedure for constructing a tangent to a point on a circle by means of a perpendicular. Often, depending upon the type of drawing, this method is the most practical. Remember that a tangent to a circle is perpendicular to a radius at the point of tangency.

(1) With P as the point on the circle, draw a line through P and extend it to some convenient point X.

(2) Using P as the center, construct line AB perpendicular to line OX at point P.

(3) Line AB is tangent to the circle at point P.

Exercises (032):

1. Using the geometric construction method, construct a line tangent to a circle.

2. Using the perpendicular method, construct a line tangent to a circle.

033. Given a point outside a circle, construct a line tangent to the circle.

Constructing a Line Tangent to a Circle. The procedure for constructing a line tangent to a circle from an outside point is just as easy to do as the previous construction (see fig. 4-17.)

(1) Using P as the point, draw a line from 0, the center of the circle, to the point P.

(2) Bisect the line OP; at the point of the bisector, point A, strike an arc with AO as the radius.

(3) Where the arc strikes the circle forming point T, draw the tangent PT.

Exercises (033):

1. Construct a tangent to a 3-inch-diameter circle from a point 2 inches from the center of the circle at an angle of 269°.

034. Draw an arc tangent to a given line and circle, and draw an arc tangent to two circles.

Given a Line, Circle, or Arc.

(1) Take the given radii R1 and R2; strike an arc with 0 as the center (see fig. 4-18.)

(2) Draw a line CD parallel to the given line AB at a distance of R2.

(3) Where the arc R1 + R2 crosses line CD, strike an arc that is tangent to line AB and the circle.

Drawing Tangent Arcs. In this type of construction, two conditions may exist. In one case, the centers of the given arc are outside the required arc; in the other, the centers are included inside the required arc.

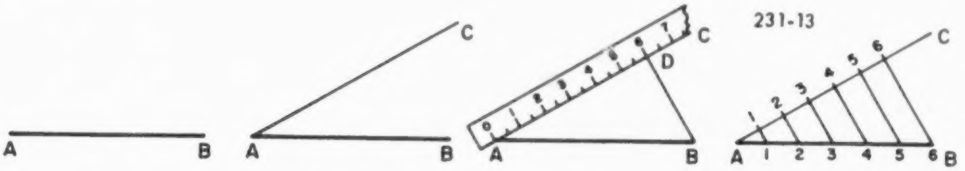


Figure 4-13. Dividing a line into equal parts.

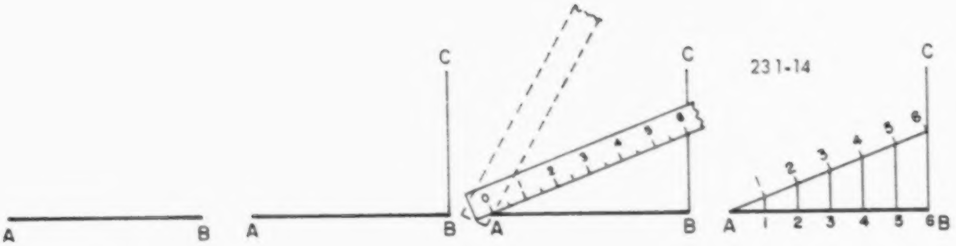


Figure 4-14. Dividing a space into equal parts.

(1) Given R1, R2, and R3, with 0 as the center, strike an arc with R1+R2.

(2) With 0′ as the center of the second arc or circle, strike an arc R2+R3 that intersects the first arc at point P.

(3) Using P as the center and radius R2, strike the required arc.

The center of the circle is included inside the required arc. Use figure 4-19 as you practice this procedure, given the radii R1, R2, and R3.

(1) Using 0 and 0′ as centers, take R1-R3 and strike the first arc.

(2) Take R2-R3 and strike the second arc, forming point P.

(3) At point P, using R3, you can strike an arc that is tangent to both circles 0 and 0′.

Exercises (034):

1. Draw an arc tangent to a given line and circle.

2. Draw an arc tangent to two circles:

4-5. Construction of a Plane Geometric Figure

Remember that a plane is a two-dimensional surface. A plane figure is a figure completely inclosed on all sides and which lies on a flat surface. For example, a square cannot exist alone in nature. When we speak of a square, we are actually speaking of one surface or plane of a cube. So drawing the planes of a figure will aid you in developing your drawing accuracy, not only in the application of geometric construction principles, but also in the construction of three-dimensional figures. The construction of a plane geometric figure has no right or wrong way, but some procedures are more accurate than others. We will begin with the triangle and cover as many shapes and procedures as necessary.

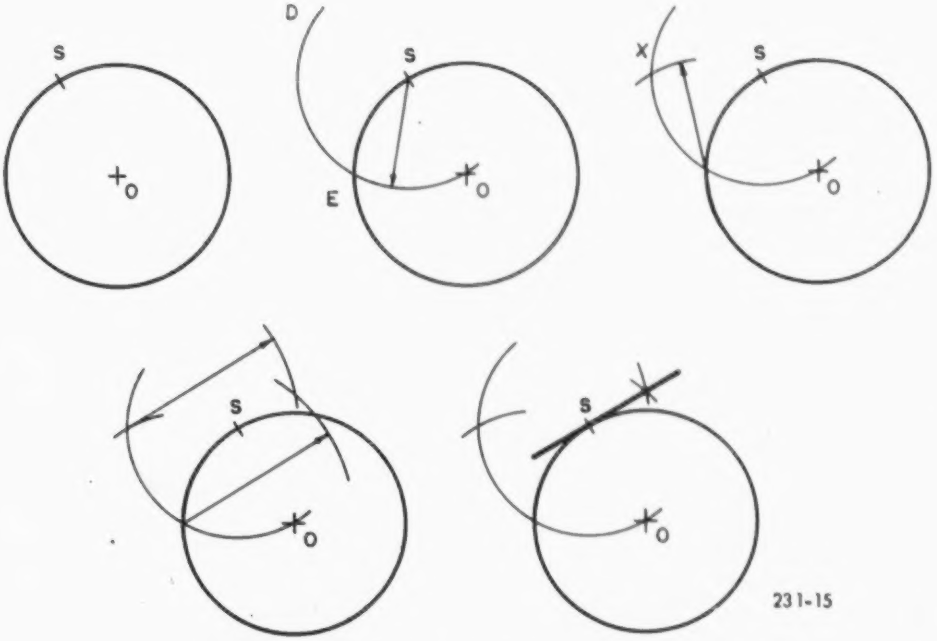


Figure 4-15. Constructing a line tangent to a point on a circle.

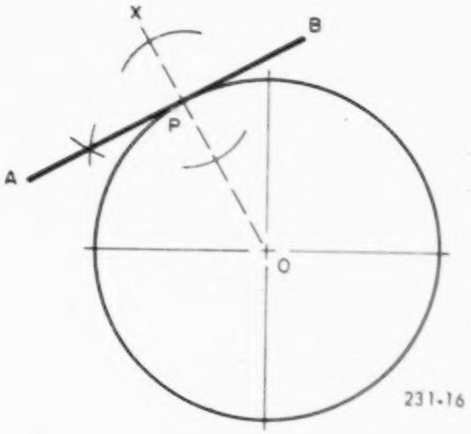


Figure 4-16. Constructing a line tangent by means of a perpendicular.

035. Find the lengths of given sides in given triangles, and draw a triangle according to specifications.

Construction of a Triangle with Three Given Sides. As you practice, follow this procedure (see fig. 4-20):

(1) Draw one side, such as side A, in any position.

(2) With side B as a radius, strike an arc from either end of the line A.

(3) With side C as a radius, strike an arc from the opposite end of A and intersect the first arc.

(4) Draw a line from the ends of side A to the point of intersection.

Construction of a Right Triangle with Hypotenuse and One Side Given. Figure 4-21 illustrates the following procedure for constructing a right triangle with hypotenuse (P) and a side (T) given.

(1) Draw a line (any position) and mark off BC equal to the length of line P.

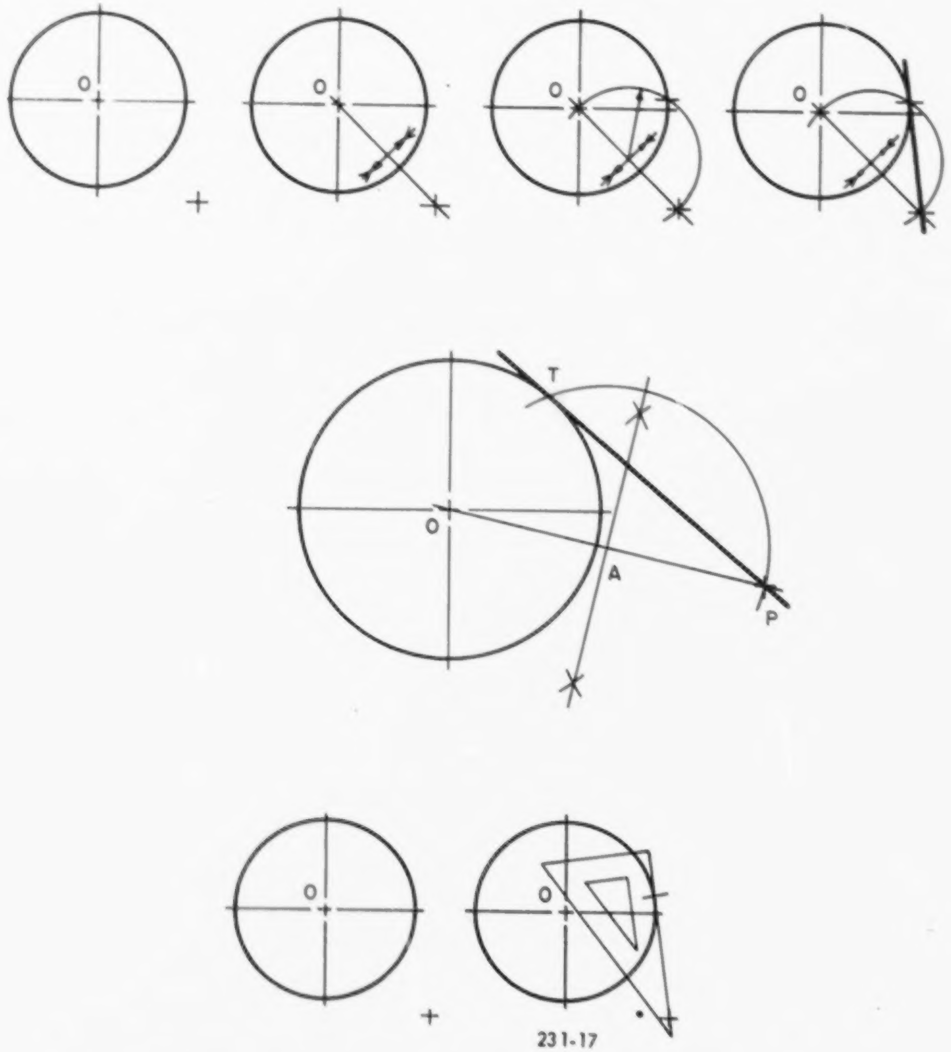


Figure 4-17. Constructing a line tangent to a circle from an outside point.

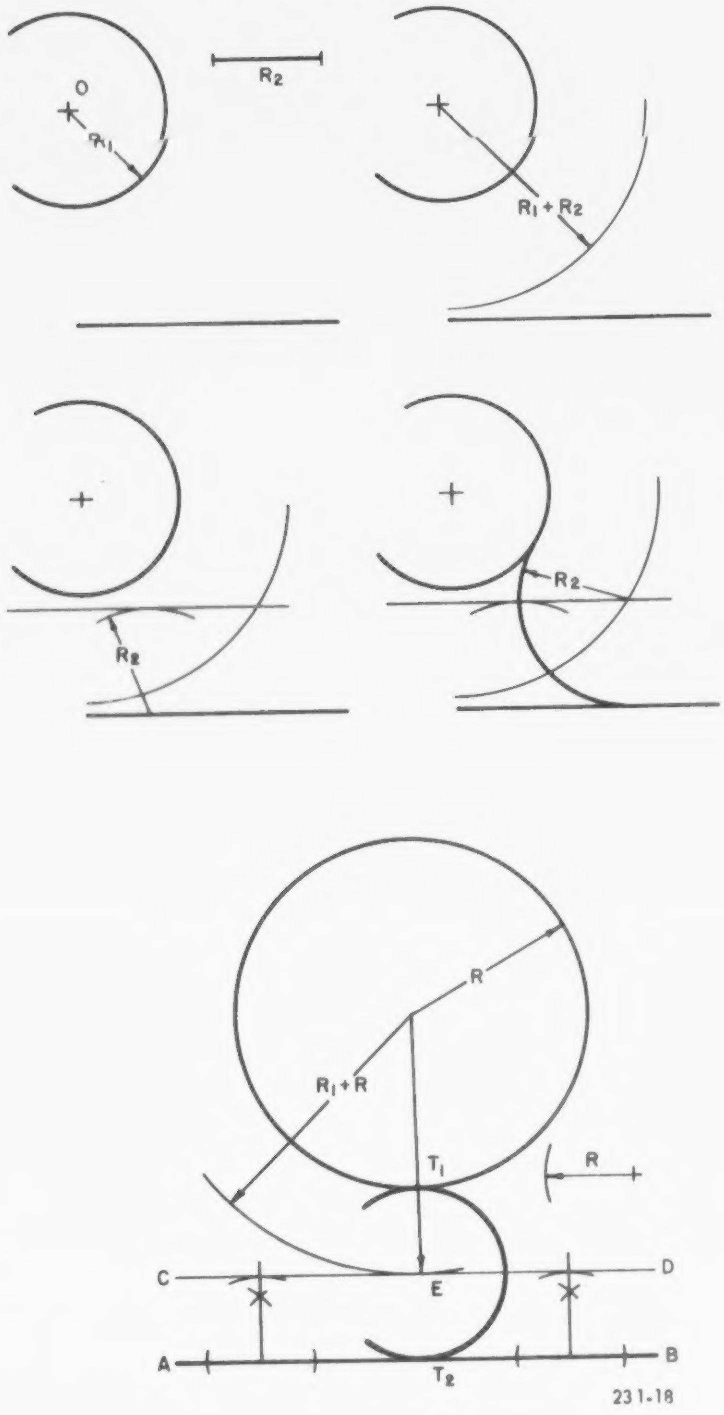
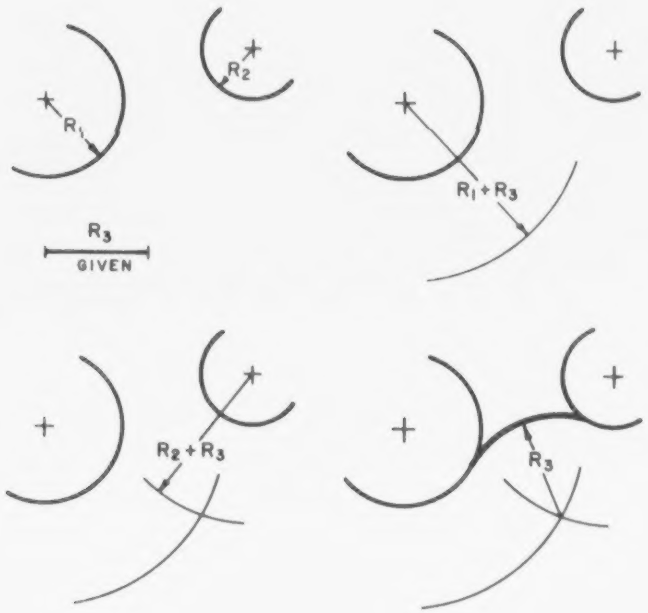

O
R_1
R_2
$R_1 + R_2$
R_2
R_2
R
$R_1 + R$
T_1
R
C
D
E
A
B
T_2
231-18

Figure 4-18. Constructing an arc tangent to a given arc and line.



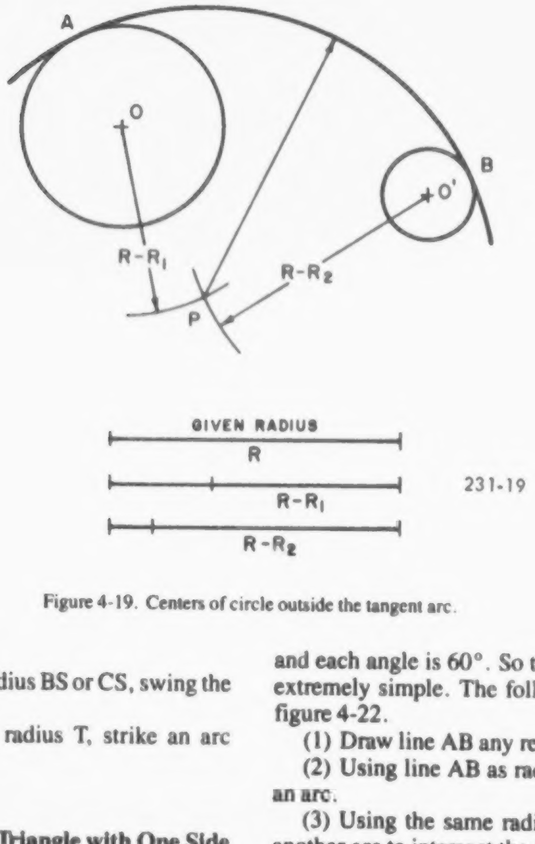


Figure 4-19. Centers of circle outside the tangent arc.

(2) Bisect the line BC (point S).

(3) Using point S as center and radius BS or CS, swing the semicircle.

(4) With point C as center and radius T, strike an arc cutting the semicircle at point D.

(5) Draw lines BD and CD.

Construction of an Equilateral Triangle with One Side Given. Recall that all sides of an equilateral triangle are equal and each angle is 60°. So the construction of this triangle is extremely simple. The following procedure is illustrated in figure 4-22.

(1) Draw line AB any required length.

(2) Using line AB as radius and point B as center, swing an arc.

(3) Using the same radius and point A as center, swing another arc to intersect the first arc.

(4) Draw sides AC and BC.

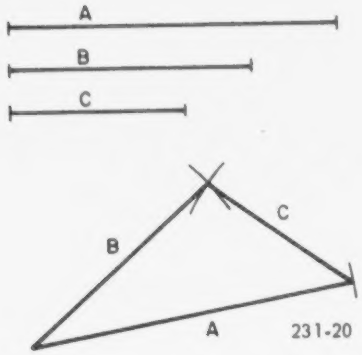


Figure 4-20. Constructing a triangle with three given sides.

Construction of an Equilateral Triangle, Using a T-square and Triangle. This is a convenient method, particularly if the base of the triangle is horizontal. Figure 4-23 illustrates the following procedure.

(1) Place a 30°-60° triangle against a T-square and draw a line which makes a 60° angle with one end of given base AB.

(2) Draw a line which makes a 60° angle with the other end of base AB.

(3) The intersection of these two lines at point C completes the triangle.

Exercises (035):

1. Draw a triangle with the hypotenuse 1 ¼ inches and one side 3/4 inch. Find the length of the other side.

2. Using a T-square and triangle, draw an equilateral triangle with a height of 2 inches.

036. Construct a square according to specifications.

Construction of a Square with One Side Given. As in the construction of many other figures, there are several ways to draw a square. The following method, illustrated in figure 4-24, should come in handy at times for drawing a square at any angle.

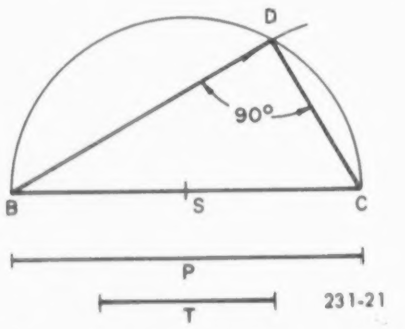


Figure 4-21. Constructing a right triangle with hypotenuse and one side.

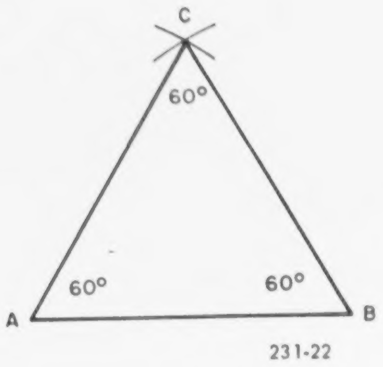


Figure 4-22. Constructing an equilateral triangle with one given side.

(1) Draw a perpendicular to given side BC at point B.

(2) Using point B as center and radius BC, strike an arc to intersect the perpendicular (point D).

(3) With points C and D as centers and radius BC, strike arcs which intersect (point E).

(4) Draw lines DE and EC to complete the square.

Construction of a Square with Distance Across Corners Given, Using T-square and Triangle. The following method to make this construction is illustrated in figure 4-25.

(1) Through points A and B of given distance AB, draw lines AC and BD, using a T-square and a 45° triangle.

(2) Turn the triangle over and draw lines AD and BC in the other direction through the same points.

(3) These lines which intersect at points C and D complete the square.

Exercises (036):

1. Construct a square with one given side.

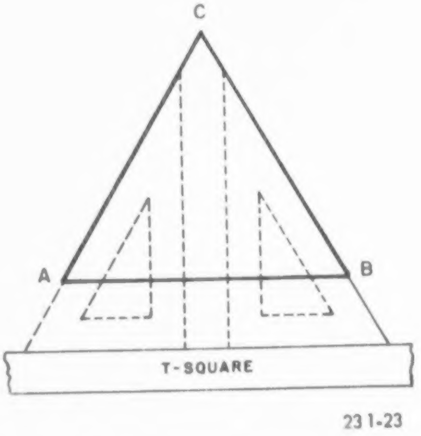


Figure 4-23. Constructing an equilateral triangle with T-square and triangle.

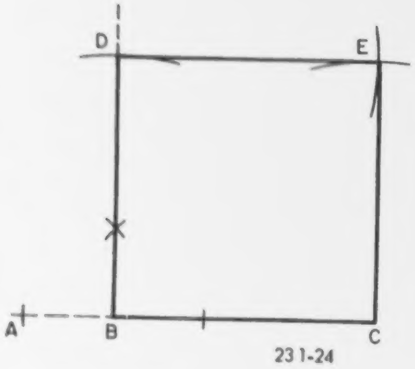


Figure 4-24. Constructing a square with one side given.

037. Demonstrate two methods of constructing a regular pentagon.

Constructing a Regular Pentagon Inscribed within a Given Circle. The following procedure to construct this pentagon is illustrated in figure 4-26.

(1) Draw any diameter, AB, of the circle.

(2) Construct radius OC perpendicular to diameter AB.

(3) Bisect OB to find point D.

(4) Using point D as center and CD as radius, swing an arc cutting the diameter AB to find point E.

(5) Using C as center and CE as radius, swing an arc cutting the circle at point F.

(6) Draw chord CF. This chord is one side of the pentagon.

(7) Using the same radius CE which is equal in length to chord CF, step off the remaining points around the circle and connect them with chords.

Constructing a Regular Pentagon with Length of One Side Given. The following procedure to construct a pentagon on given side AB is illustrated in figure 4-27.

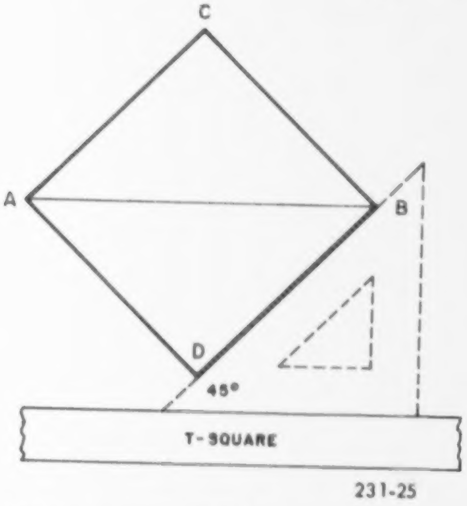


Figure 4-25. Constructing a square with the distance across the corners given.

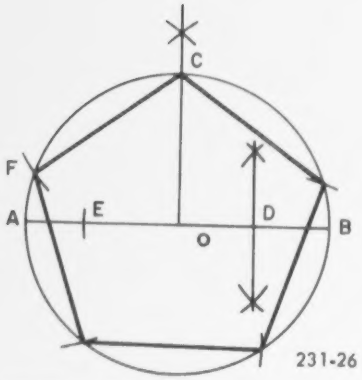


Figure 4-26. Constructing a regular pentagon inscribed within a given circle.

(1) Using given side AB as radius and point A as center, draw a semicircle to cut the construction line extended from side AB.

(2) Divide the semicircle into five equal parts by using dividers. (This may require several attempts before you have the divisions accurate.)

(3) Through division 2, draw a radial line A2. This line is one side of the pentagon.

(4) Through divisions 3 and 4, draw radial lines, extending them beyond the semicircle.

(5) Using side AB as radius and point B as center, swing an arc which cuts extended line A4 to find point D. Using the same radius and division 2 as center, swing an arc which cuts extended line A3 to locate point C.

(6) Connect the points thus found to complete the pentagon.

Exercises (037):

1. Using a diameter of 2½ inches, construct a pentagon inscribed in the circle.

2. Given one leg of a pentagon 1¼ inches long, construct a regular pentagon using the method described in figure 4-27.

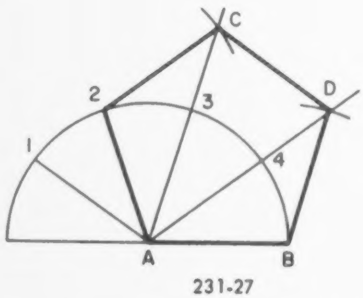


Figure 4-27. Constructing a regular pentagon with length of one side given.

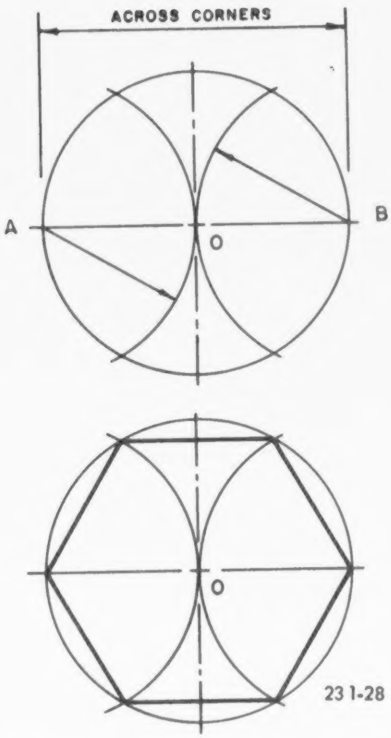


Figure 4-28. Constructing a regular hexagon with width across corners given.

038. Demonstrate three methods of constructing a hexagon.

Construction of a Regular Hexagon. There are several methods of constructing regular hexagons. The method you use in your drawings, as well as the particular situation, is largely up to you. Hexagon constructions are common in both mechanical and architectural drawing. An example is the hexagonal-headed bolt frequently represented in mechanical drawings. Now, let's cover three of the several ways to construct these figures.

Constructing a regular hexagon with the width, AB, across corners given. The procedure which follows is illustrated in figure 4-28.

(1) Draw a circle with given width AB as its diameter.

(2) With the same radius (one-half of diameter AB) and using points A and B as centers, draw arcs intersecting the circle as shown.

(3) Draw the chords, as shown, thus completing the hexagon.

Construction of a regular hexagon, using T-square and triangle. This method is often used when one side is horizontal with your drawing. Figure 4-29 illustrates the following procedure.

(1) From the ends of the given line, AB, draw lines 1, 2, 3, and 4 at an angle of 60° with AB.

(2) Draw two construction lines making a 30° angle with line AB.

(3) From points where one leg of each 30° angle intersects a leg of the 60° angle lying opposite it on line AB, construct parallels to line AB. These two parallels and the four legs of the 60° angles intersect to form a regular hexagon.

Construction of a regular hexagon with width across flats given. This method of construction is illustrated in figure 4-30. Refer to this illustration as you follow the procedure.

(1) Draw a circle with line CD, the width across the flats, as the diameter.

(2) Draw the vertical and horizontal center lines.

(3) Using the 30°-60° triangle and T-square, draw the sides of the hexagon tangent to the inscribed circle.

Exercises (038):

1. Construct a regular hexagon with width across the flats as described in figure 4-30.

2. Construct a regular hexagon using a T-Square and triangle.

3. Construct a regular hexagon with the width across corners given.

039. Demonstrate two methods of constructing a regular octagon.

Construction of a Regular Octagon. Two methods for constructing a regular octagon are described below. First, we'll cover the procedure used when the width across flats is given, and then when the width across corners is known.

Constructing a regular octagon with width across flats given. Refer to figure 4-31 as you follow this procedure.

(1) Construct a square having sides equal to the given width across flats (AB in the figure).

(2) Draw the diagonals of the square to locate point 0, their intersection.

(3) Using OA (or OB) as radius, swing an arc from each corner of the square to intersect two sides of the square.

(4) Connect the points (intersections) thus found to complete the octagon.

Constructing a regular octagon with the distance across corners given. Figure 4-32 illustrates the following procedure.

(1) Draw a circle whose diameter is equal to the given distance across corners.

(2) Using a T-square and triangle, draw horizontal diameter AB and vertical diameter CD.

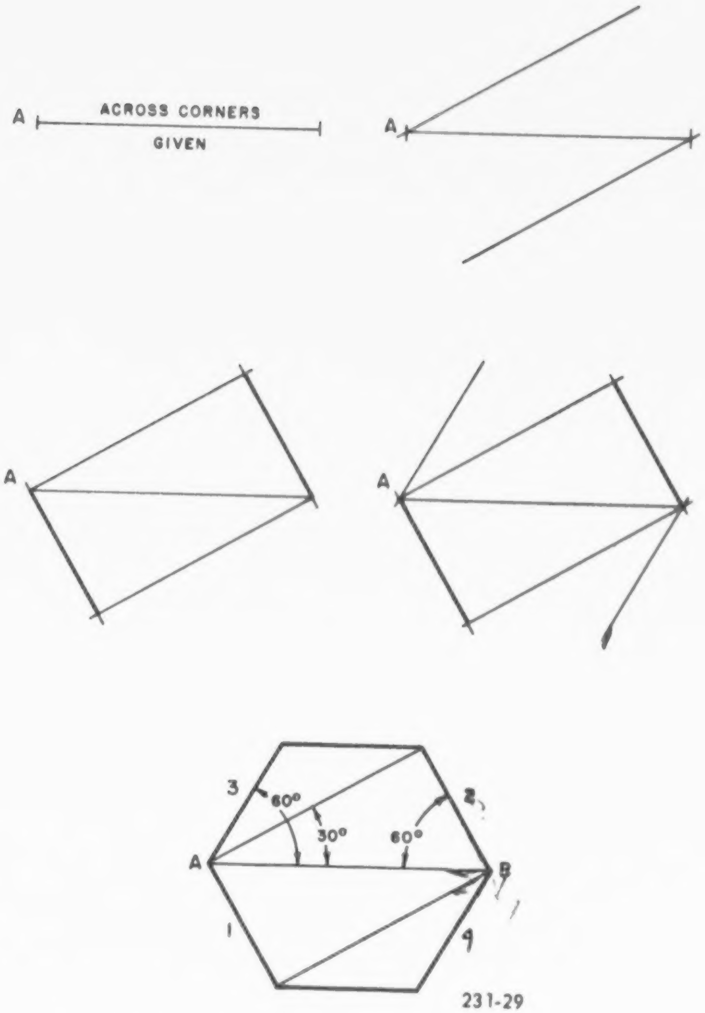


Figure 4-29. Constructing a regular hexagon using T-square and triangle.

(3) Using a T-square and a 45° triangle, draw diameters EF and GH.

(4) Connect the points where the diameters intersect the circle to complete the octagon.

Exercises (039):

1. Draw a regular octagon using the across-flats method.

2. Draw a regular octagon using the across-corners method.

040. Demonstrate five methods for constructing an ellipse.

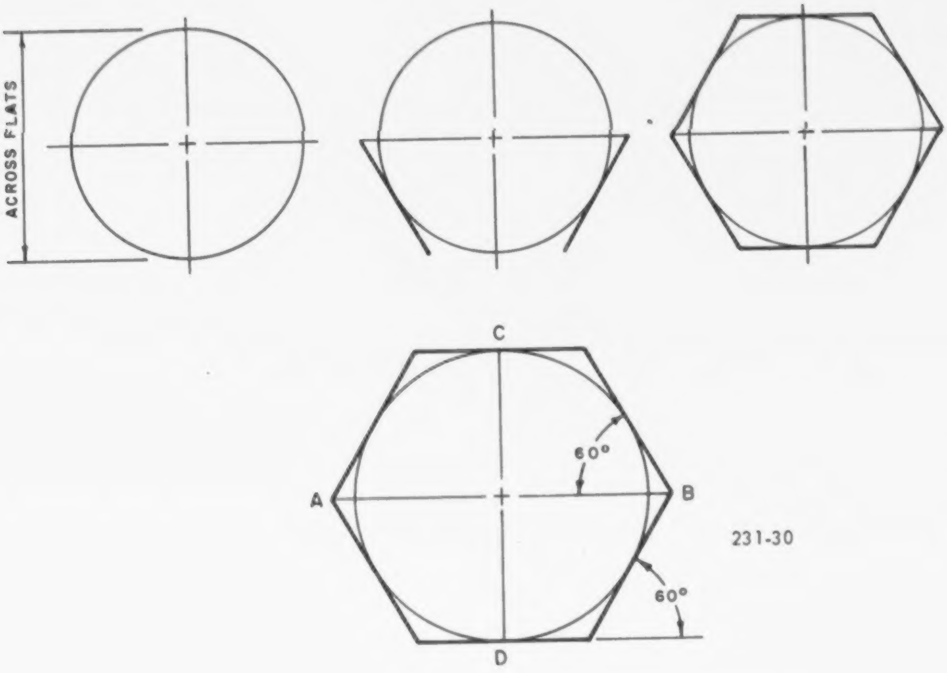
An Ellipse Constructed by Foci Method—True Ellipse. This method is frequently used because it is very accurate and particularly useful for constructing an ellipse with a major axis of between 2 inches and 6 inches in length. With major axis AB and minor axis CD given, the following procedure is illustrated in figure 4-33.

(1) Locate the foci, points E and F, by swinging an arc of radius AO (half of major axis) and point C (one end of minor axis) as center.

(2) Divide the distance between points E and O on the major axis into a number of units, such as 1, 2, 3, 4, 5, etc. (For larger ellipses, more units are required to draw a smooth curve.)

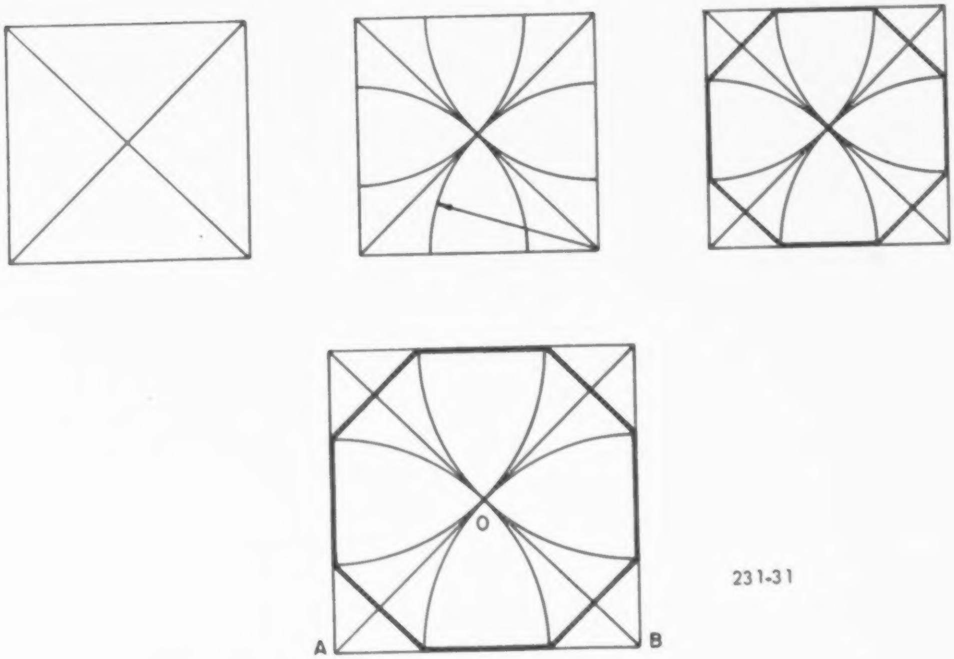
(3) Using A1 as radius and point E as center, strike arcs in quadrants 2 and 3. Then, using the same radius and point F as center, strike arcs in quadrants 1 and 4.

(4) With B1 as radius and point F as center, strike arcs intersecting the first arcs in quadrants 2 and 3 (marked points P) in each quadrant. Using the same radius and point E as


ACROSS FLATS
C
60°
A
B
60°
D

231-30

Figure 4-30. Constructing a regular hexagon with width across flats given.



231-31

Figure 4-31. Constructing a regular octagon with width across flats given.

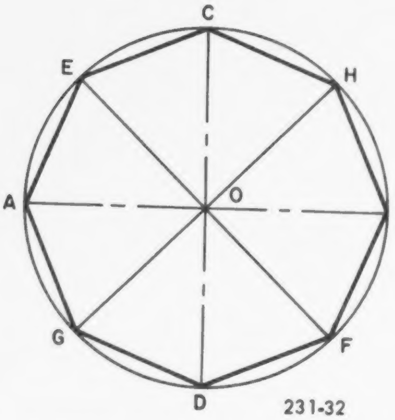


Figure 4-32. Constructing a regular octagon with distance across corners given.

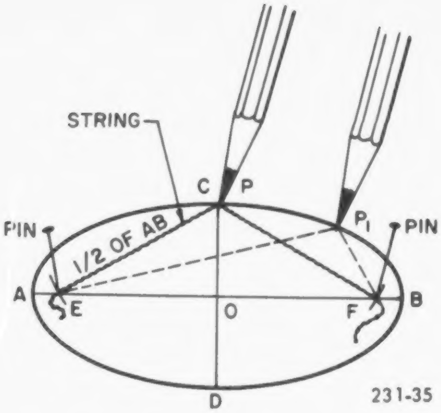


Figure 4-34. Constructing an ellipse by pin and string method.

center, repeat this operation. Thus, arc intersections (points P) in each quadrant are established.

(5) Using each of the remaining points on EO, measured radii A2, B2, A3, B3, etc. Repeat the process described above, using the same centers.

(6) Use the irregular curve in joining the plotted points (arc intersections) to draw the ellipse.

An Ellipse Drawn by Pin and String Method. This method is not accurate enough for drafting in general. However, it is very handy for large constructions. For instance, it is a common method of laying out ellipses for flower gardens, etc.

Recall that an ellipse may be generated by a point moving in such a way that the sum of its distances from two points (the foci) is constant and equal to the major axis. This principle is shown by the following procedure and illustrated in figure 4-34. The given major and minor axes are AB and CD, respectively.

(1) Locate the foci, points E and F, as described in the foci method.

(2) Fasten the end of a string (of length equal to distance ECF) at points E and F with pins so that there will be no slack when the midpoint of the string is held by a pencil (or other marking device) at point C.

(3) By moving the pencil around the maximum orbit allowed by keeping the string taut, the ellipse will be described. The method of movement is shown in illustration (from point P to P1, etc.)

An Ellipse Constructed by Trammel Method—True Ellipse. This method is preferred by many draftsmen. If you

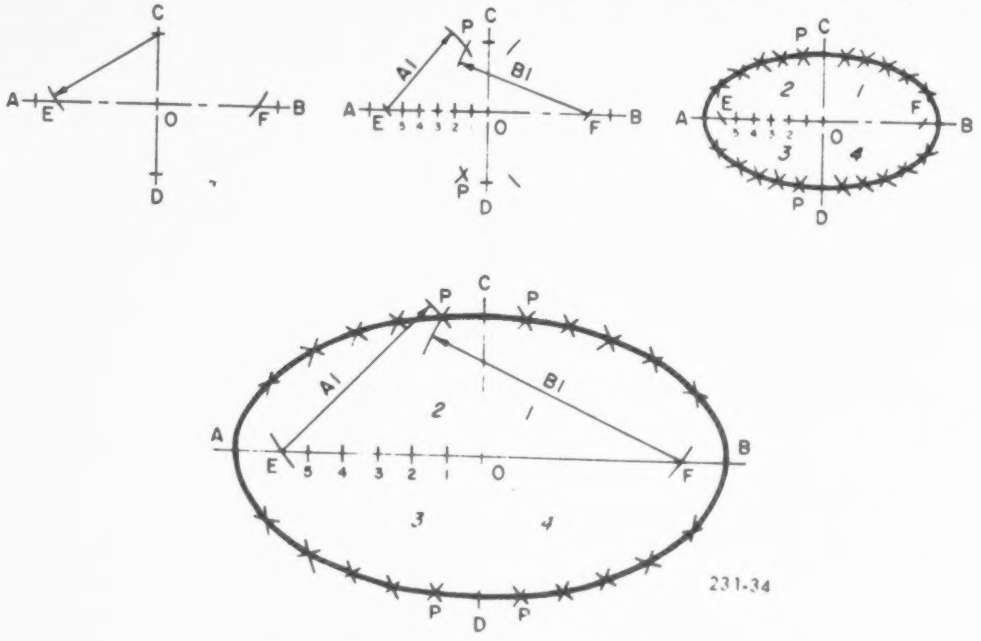


Figure 4-33. Constructing an ellipse by foci method.

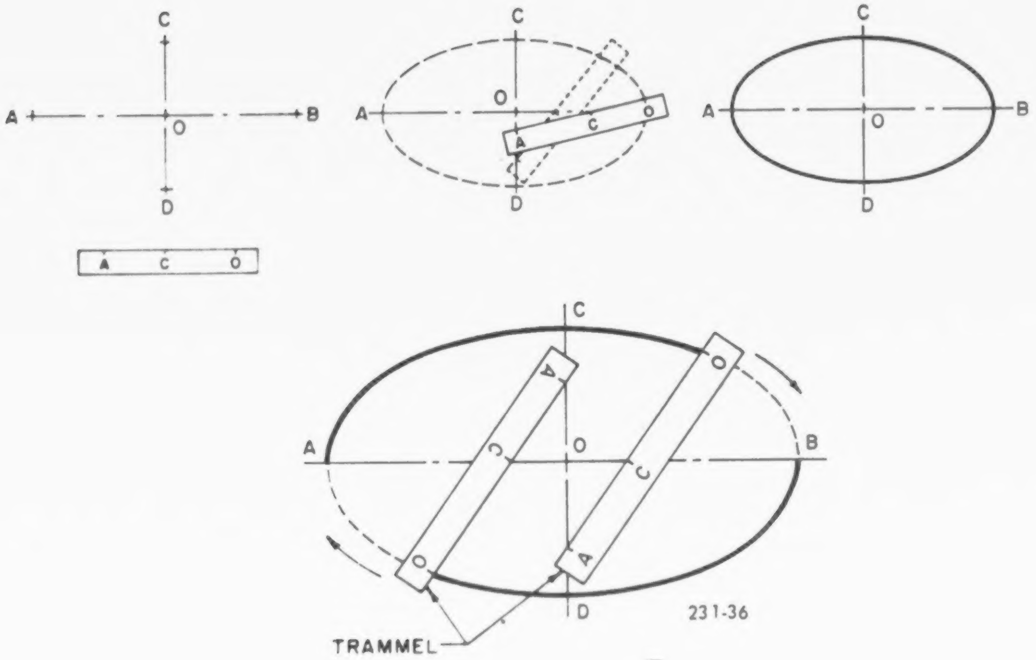


Figure 4-35. Constructing an ellipse by trammel method.

are careful to be accurate, you will find this method simple and fast. Refer to figure 4-35 as you practice the following procedure.

(1) On the straight edge of a slip of paper, cardboard, or plastic, mark half the distance (AO) of the major axis, and then mark half the distance (CO) of the minor axis.

(2) Place the trammel so that point A is on the minor axis and point C is on the major axis. Point O is then marked on the curve.

(3) Locate additional points of the curve by moving the trammel to other positions, always keeping point A of the trammel on the minor axis and point C on the major axis.

(4) After you have established a sufficient number of points for the curve, draw the ellipse with an irregular curve.

An Ellipse Constructed by Four-Center Method. Although this method of construction produces an approximate ellipse, it is useful, since the use of an irregular curve is not required. Given the axes AB and CD, the following procedure is illustrated in figure 4-36.

(1) Draw line AC to connect the ends of the major and minor axes.

(2) Mark on line AC the distance CE, which is equal to AO minus CO.

(3) Draw the perpendicular bisector of AE, extending the bisector to intersect the major axis at point F and the extended minor axis at point G. These two intersection points are centers for two of the required arcs.

(4) Locate points F′ and G′ in a similar manner or, more simply, by using dividers. When using dividers, set off OG′ equal to OG and OF′ equal to OF.

(5) Using points G and G′ as centers and CG as radius, swing the two (long) arcs. Then, using points F and F′ as centers and radius FA, swing the two (short) arcs.

(6) Thus, these four arcs meet to complete the ellipse.

An Ellipse Constructed by Concentric Circle Method—True Ellipse. This is another method which you may prefer to use at times. An ellipse constructed by this method is very accurate. Refer to figure 4-37 as you practice the following procedure.

(1) Using the intersection of the given major axis BC and minor axis EF (point D) as center for the ellipse, draw two concentric circles having the major and minor axes as diameters.

(2) Draw any diametral line GH.

(3) Through points where the diametral line GH cuts the circumference of the outer circle, draw vertical lines MH and GN.

(4) At points where the same diametral line, GH, intersects the circumference of the inner circle, draw horizontal lines KM and NL.

(5) The intersection points M and N of the vertical and horizontal lines are points on the required ellipse.

(6) Next, locate point M′ by extending line GN and line KM to intersect as shown on the illustration. In a similar manner, locate point N′.

(7) Thus, four points are established on the ellipse by drawing one diametral line.

(8) Repeat the entire procedure several more times to locate enough points so that a smooth ellipse can be drawn by use of an irregular curve.

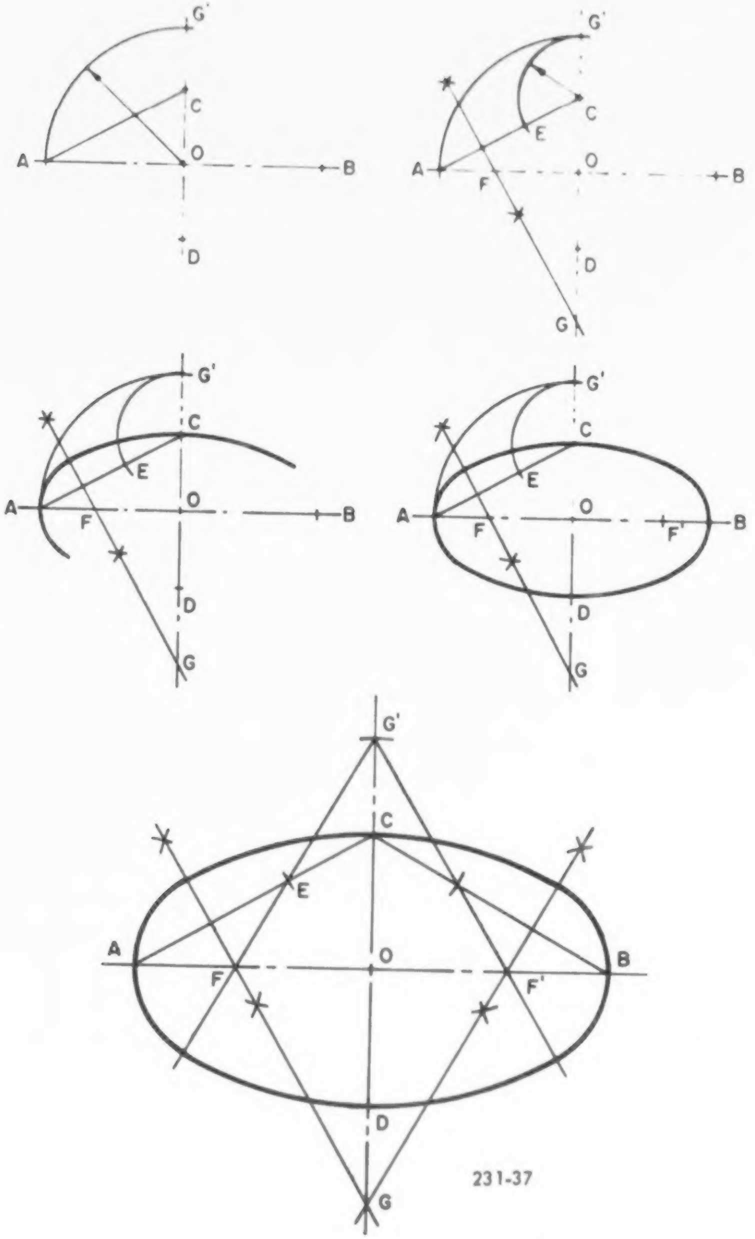


Figure 4-36. Constructing an ellipse by four-center method.

Exercises (040):

1. Construct an ellipse using the foci method.

2. Construct an ellipse using the pin and string method.

3. Construct an ellipse using the trammel method.

4. Construct an ellipse using the four-center method.

5. Construct an ellipse using the concentric circle method.

6. Which of these are true ellipses?

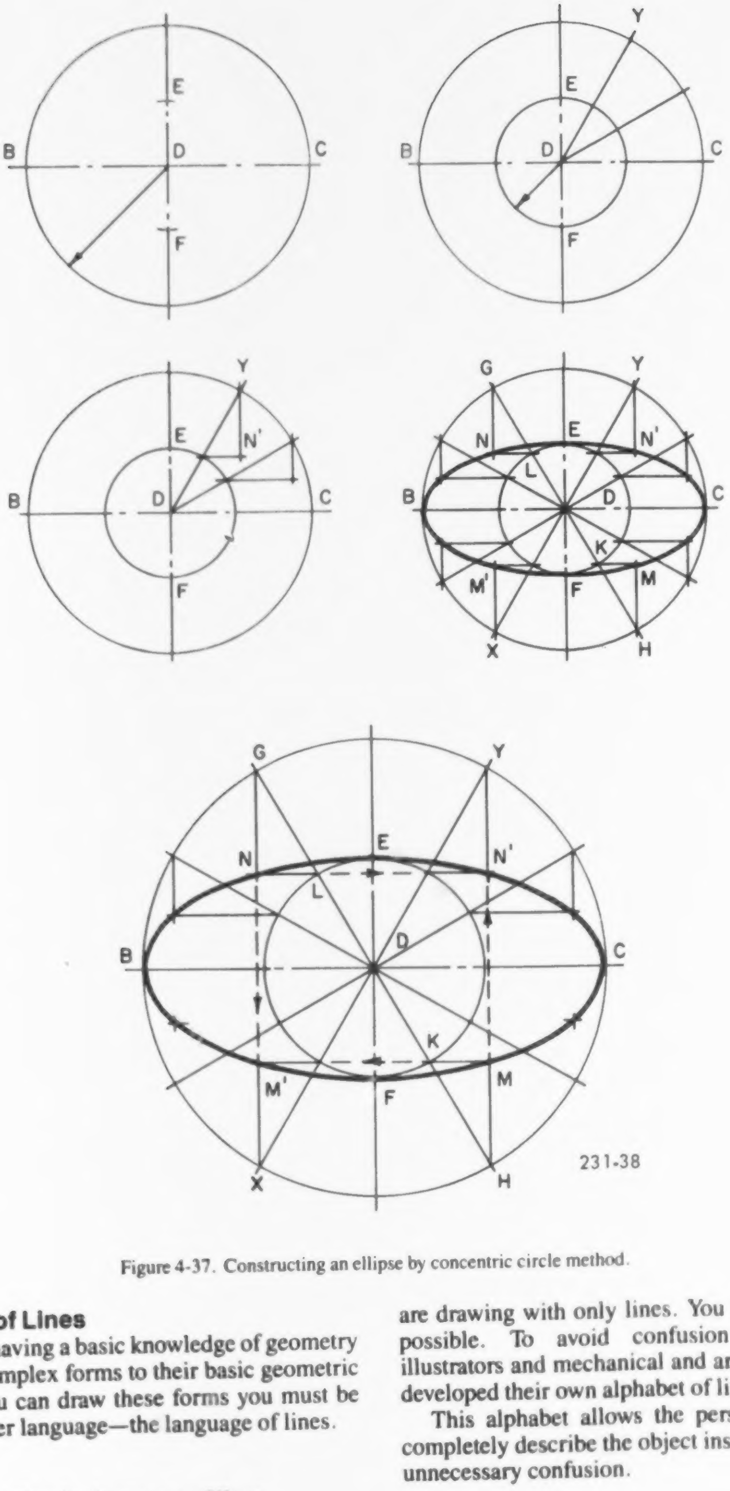


Figure 4-37. Constructing an ellipse by concentric circle method.

4-6. The Language of Lines

You have seen how having a basic knowledge of geometry can help you reduce complex forms to their basic geometric forms. Now before you can draw these forms you must be familiar with yet another language—the language of lines.

041. State the necessity for the language of lines.

In order for you the illustrator to draw an object correctly, you must be able to completely describe the object that you are drawing with only lines. You must do this as clearly as possible. To avoid confusion and misinterpretation, illustrators and mechanical and architectural designers have developed their own alphabet of lines.

This alphabet allows the person drawing an object to completely describe the object inside and out while avoiding unnecessary confusion.

Exercises (041):

1. Why is it necessary to be familiar with different types of lines?

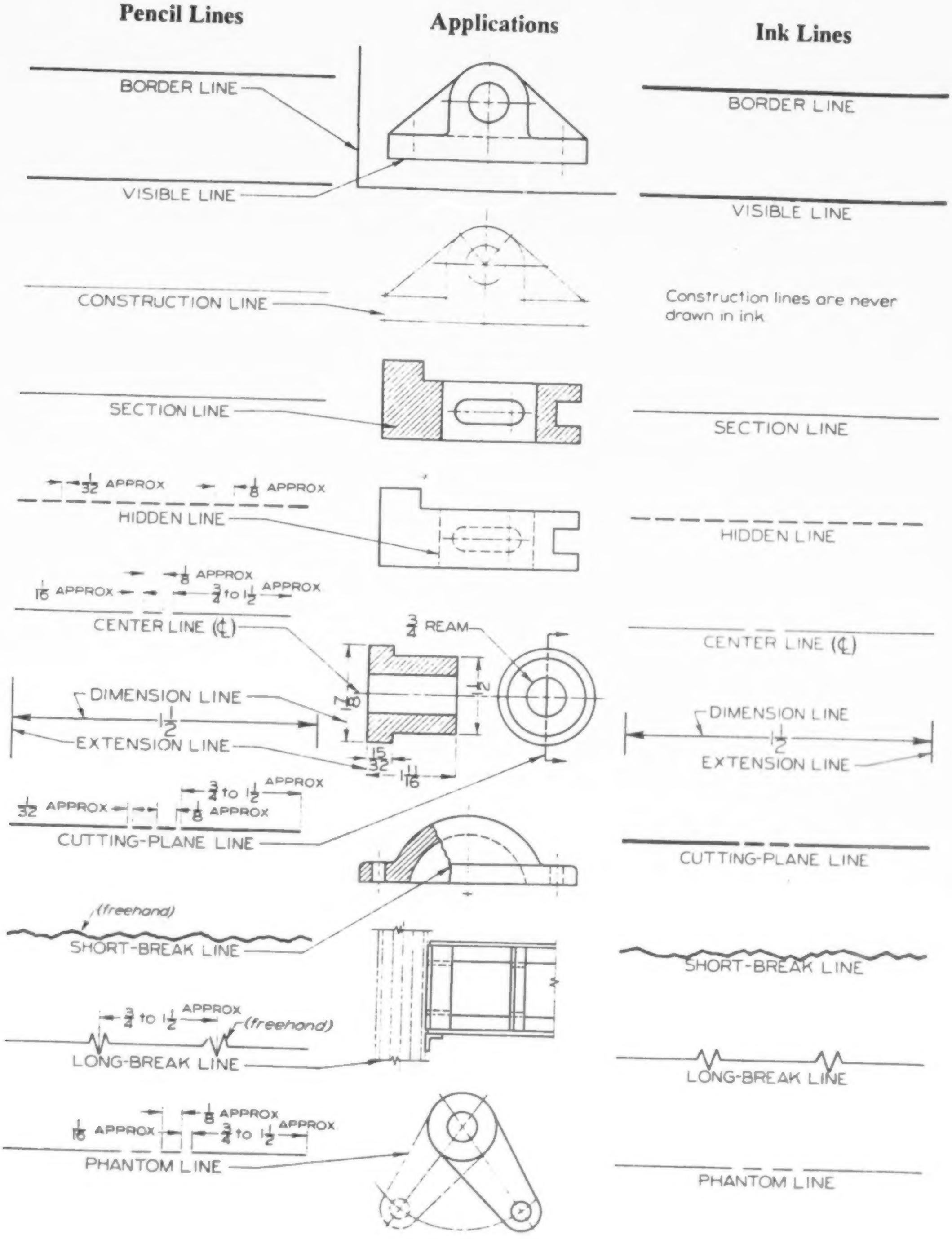

Pencil Lines
Applications
Ink Lines
BORDER LINE
BORDER LINE
VISIBLE LINE
VISIBLE LINE
CONSTRUCTION LINE
Construction lines are never drawn in ink
SECTION LINE
SECTION LINE
1/32 APPROX
1/8 APPROX
HIDDEN LINE
HIDDEN LINE
1/8 APPROX
1/16 APPROX
3/4 to 1 1/2 APPROX
CENTER LINE (℄)
CENTER LINE (℄)
3/4 REAM
DIMENSION LINE
1 1/2
EXTENSION LINE
7/8
1/2
15/32
1 11/16
DIMENSION LINE
1 1/2
EXTENSION LINE
3/4 to 1 1/2 APPROX
1/32 APPROX
1/8 APPROX
CUTTING-PLANE LINE
CUTTING-PLANE LINE
(freehand)
SHORT-BREAK LINE
SHORT-BREAK LINE
3/4 to 1 1/2 APPROX
(freehand)
LONG-BREAK LINE
LONG-BREAK LINE
1/8 APPROX
1/16 APPROX
3/4 to 1 1/2 APPROX
PHANTOM LINE
PHANTOM LINE

Figure 4-38. Alphabet of lines.

042. Given a list of definitions of lines, match the line corresponding to each definition.

The Alphabet of Lines. There are 12 different lines commonly used today. As you study the description of these lines, refer to figure 4-38.

Border line. A heavy, solid line used to establish the border area of your drawing surface. It is the heaviest line used.

Visible line. A medium weight line used to establish the visible outline of your drawn object.

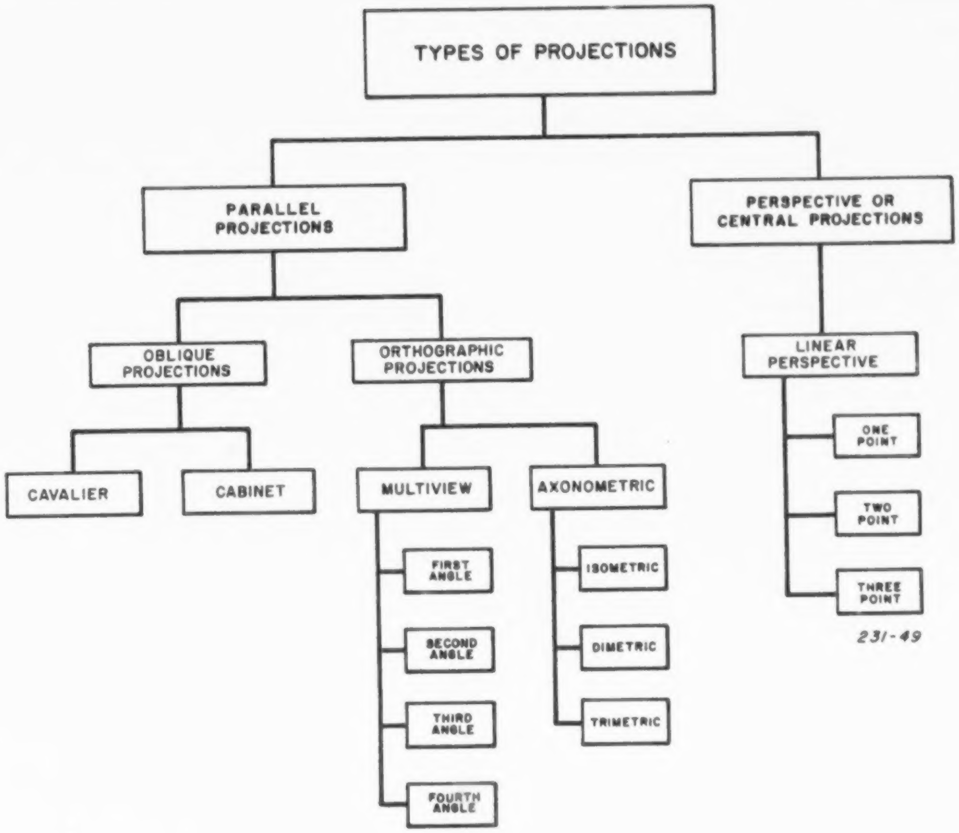

TYPES OF PROJECTIONS
PARALLEL PROJECTIONS
PERSPECTIVE OR CENTRAL PROJECTIONS
OBLIQUE PROJECTIONS
ORTHOGRAPHIC PROJECTIONS
LINEAR PERSPECTIVE
CAVALIER
CABINET
MULTIVIEW
AXONOMETRIC
ONE POINT
TWO POINT
THREE POINT
FIRST ANGLE
SECOND ANGLE
THIRD ANGLE
FOURTH ANGLE
ISOMETRIC
DIMETRIC
TRIMETRIC
231-49

Figure 4-39. Projection classifications.

Construction line. An extremely light line used for general layout work in your drawing. Construction lines are never drawn in ink.

Section line. A medium light line used to indicate a cross-section area of your drawing.

Hidden line. A medium weight, dashed line used to show necessary details of the object hidden from view. The dashes are drawn approximately 1/8" long and spaced approximately 1/32" apart.

Center line. A medium light line that denotes the physical center of the drawn object. The center line is broken in the middle by a 1/8" dash set 1/16" apart.

Extension line. A short, light line that extends from the visible lines both vertically and horizontally. Extension lines are used in conjunction with dimension lines to describe the measurement of the drawn object.

Dimension line. A light line that is drawn between extension lines that show the area and direction of measurement. These lines are usually broken in the center to allow for dimension placement. Dimension lines always have arrowheads at both ends.

Cutting plane line. A medium weight line that is broken by two 1/8" dashes set 3/4" to 1/2" from both ends. The ends are drawn perpendicular to the line and finished with arrowheads. This line is used to show where an imaginary cut in the object is made and from which direction to view the object to see the cut-away section.

Short-break line. A medium weight, erratic line that is used to show an area of the object that has been broken out. This allows you to see a partial view of the internal properties of the object. This line is drawn freehand.

Long-break line. A light weight line used to break out detail sections of long objects or to remove areas that have already been shown.

Phantom line. A light line that is drawn in the same manner as a cutting plane line. This line shows the change of positions on a moveable object.

Exercises (042):

1. Correlate the proper line with its function.
   a. This extremely light line is always drawn in pencil.
   b. This hand drawn line is medium weight and erratic. It allows you to see a partial view of the inside of an object.
   c. This line is used to indicate a cross-section.
   d. This line indicates a change in position or a movement.
   e. This line lets you look at areas not visible from one view of the object.
   f. This line has arrowheads on both ends of it.
2. What is the approximate length of the dashes used in a hidden line and how far apart are they spaced?

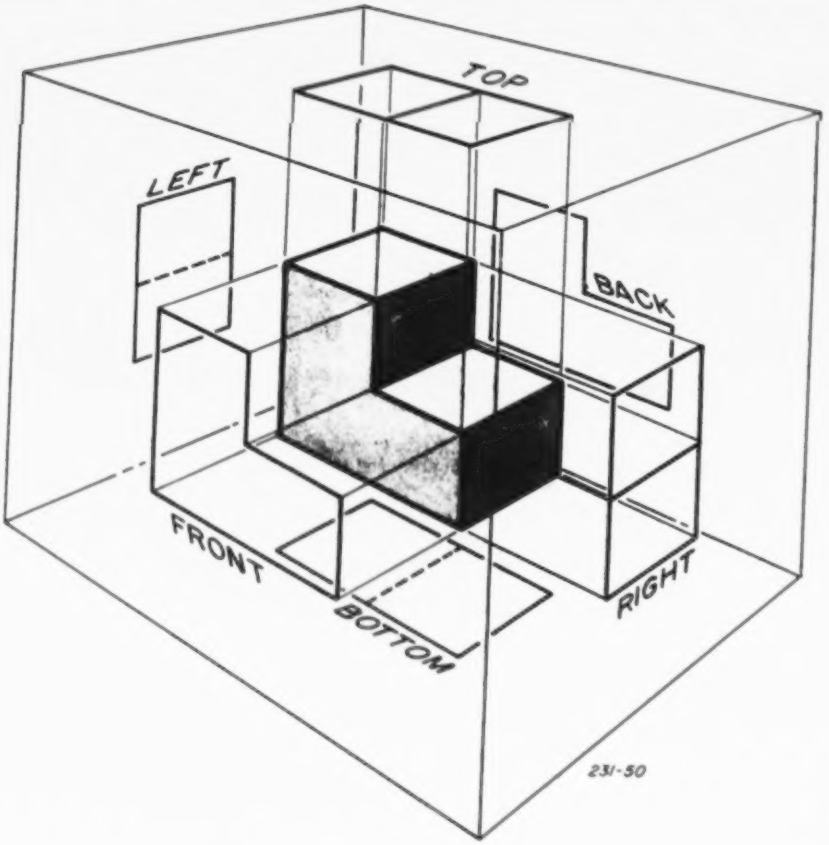


Figure 4-40. Glass box method.

4-7. Introduction to Projections

The function of any drawing is to illustrate and describe an object in sufficient clarity and detail so that it can be understood with very little explanation. Even in ancient times, people drew pictures to convey their ideas or as a substitute language. In those days a large part of drawing was confined to building construction and the fine arts. Although few drawings of that era were preserved, some interesting information can be gathered from those which were.

The crude sketches made by the early builders on clay tablets, limestone slabs, papyrus, and wood still exist for us to study. Besides having crude and bulky drawing material, the major problem confronting the early draftsman was that of representing solid objects on flat surfaces. Dimensions of length, width, and height could not be shown accurately on a two-dimensional surface. Little progress in solving this problem was made until the 15th century when Leonardo da Vinci, an Italian, discovered in his studies how to give the illusion of depth to solid objects. He developed and taught his technique until his death in 1519. After his death, mathematics scholars used various other methods to show exact measurements in their drawings.

Progress in this area was very gradual until the 17th century. During the Napoleonic era, Gaspard Monge, a Frenchman, developed a system of right-angle projections on planes set up perpendicular to each other. This system was not only measureable but is the basis for the three-dimensional representations that we know today.

The ability to think in three dimensions is a prerequisite, no matter what type of drawing you happen to be engaged in. Every drawing has a space relationship involving four factors:

(1) The observer's eye, or the station point.
(2) The object.
(3) Projection lines.
(4) The plane of projection.

In technical drawing, three kinds of projections are used: orthographic, oblique, and perspective. All three projections describe the shapes of objects, but only orthographic and oblique projections (parallel projections) describe the size of the object and show dimensional markings.

043. Specify the different types and categories of projections.

Orthographic Projections. An orthographic projection is any projection made by lines of sight which are

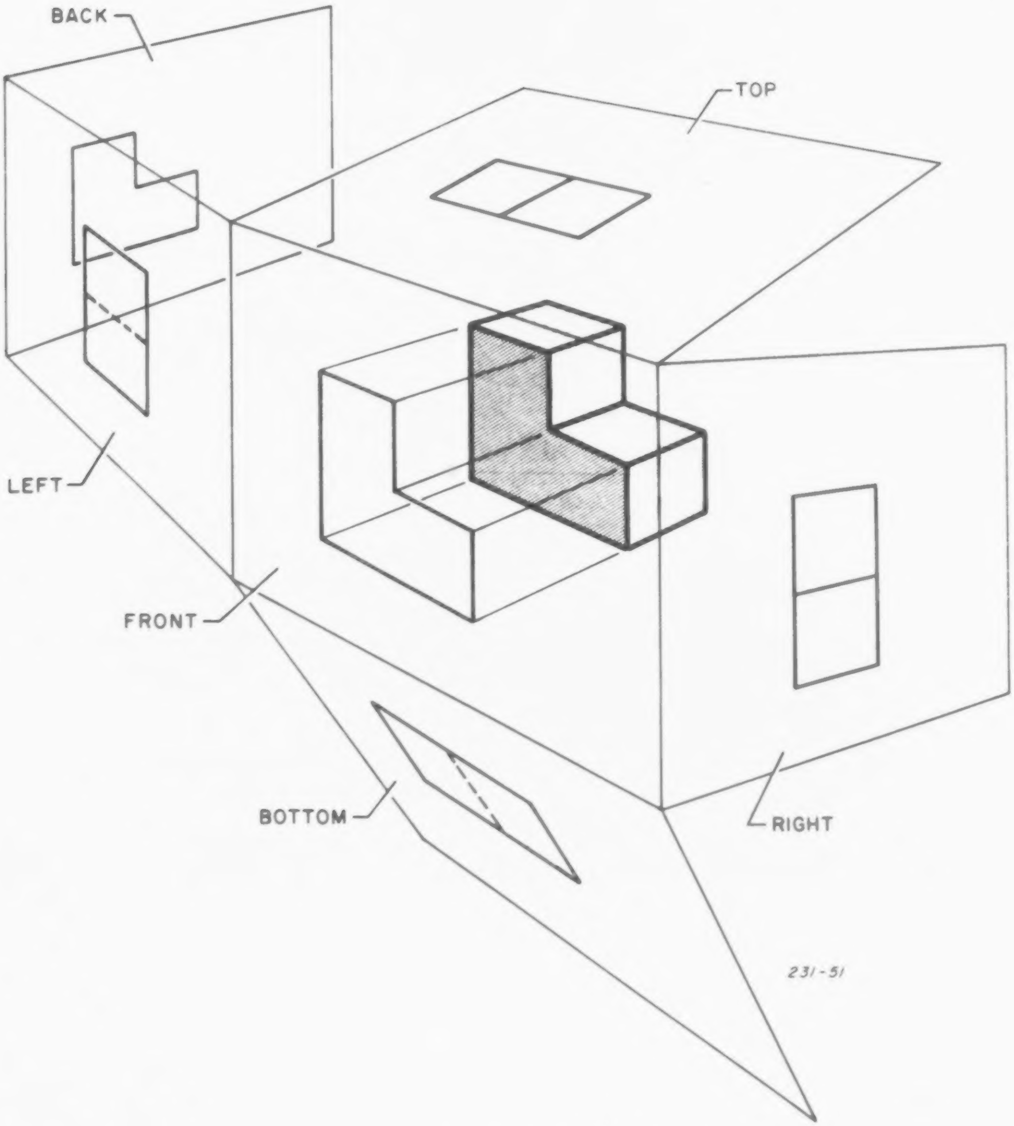


Figure 4-41. Opening the glass box.

perpendicular to the image plane. Since these projection lines are perpendicular to the same plane, they are parallel to each other. Notice in figure 4-39 that there are two types of orthographic projections, multiview and axonometric.

There are four different types of multiview drawings. These drawings make up the greater part of all engineering, industrial, and architectural drafting. Sometimes a multiview drawing is supplemented by a pictorial drawing, such as an axonometric.

Multiview drawings are made to represent a three-dimensional object drawn on a two-dimensional surface. This method of orthographic projection is relatively easy to understand. It simply consists of the observer viewing an object as if it were placed inside a glass box (see fig. 4-40). The observer is always on the outside looking in. Notice that the object is positioned so that each face is parallel with a respective surface or image plane of the glass box. The observer assumes the position of viewing one surface at a time so that his or her line of sight is perpendicular to the surface and the image plane. Thus, each face is projected and can be drawn on the appropriate image plane in its true size and shape.

Opening the glass box. To obtain all the views of the object laid out in a single plane and in the proper position, one must assume that the sides of the glass box are hinged. The partially opened box as shown in figure 4-41 has five of the six views rotating from the front view of the object, thus putting the right side view on the right of the front view, and all of the other views in their proper places as shown in figure 4-42.

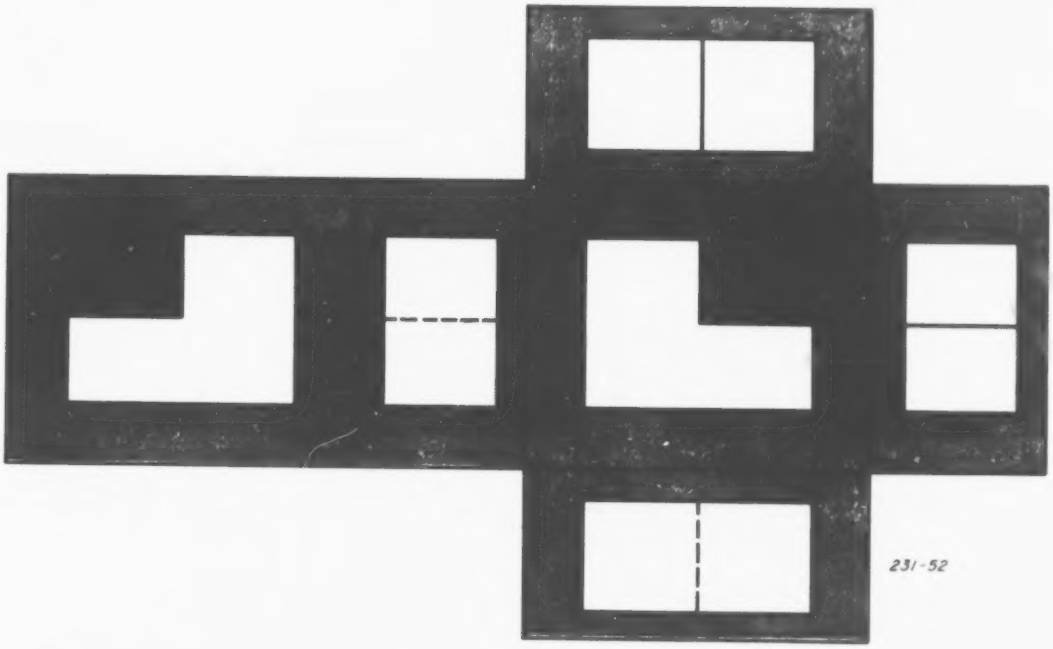


Figure 4-42. Layout of sides of glass box on paper.

Selection of views. In drawing an orthographic projection, it is necessary to select only those views that will describe the object completely. The first step is to determine the front view. This may be done by placing the object in its natural position so that the top is parallel to the top image plane, etc. The front view should be that side that shows the greatest contour or the most irregular shape. If any doubt exists concerning which view fulfills this condition, select the side with the greatest length. Foldout 1 shows an object with the three multiview projections and a pictorial, so that its true size and shape can be seen. Notice that the view selected for the front shows the greatest contour of the object. This may or may not be the actual front of the object. In this projection only the three views are essential to understand the object. Generally, it is the practice to show the side view that requires the fewest hidden lines. If a drawing becomes cluttered and confusing because of the hidden lines, the practical thing to do would be to draw the other side and eliminate the hidden lines. When there is little difference between the right-side view and the left-side view, the right side is preferred.

Exercises (043):

1. Projections are classified into what two major categories?

2. Usually, what determines which side of the object should be the front view?

3. Using the glass box theory, when are the top, front, and bottom views in the same vertical line?

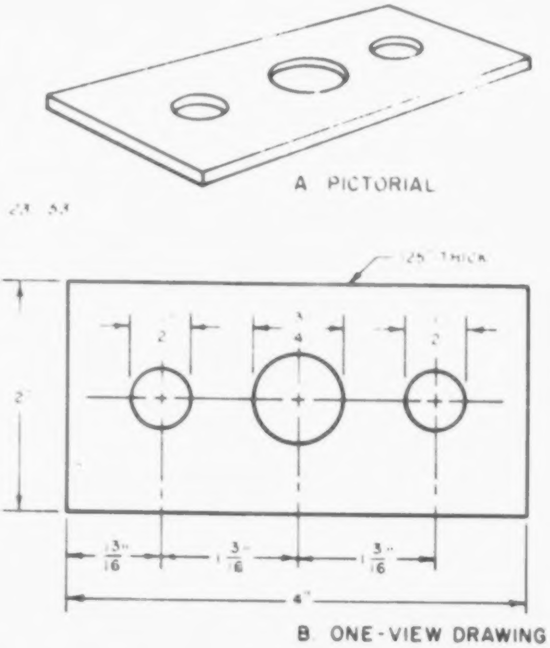


Figure 4-43. One-view drawing of a flat object.

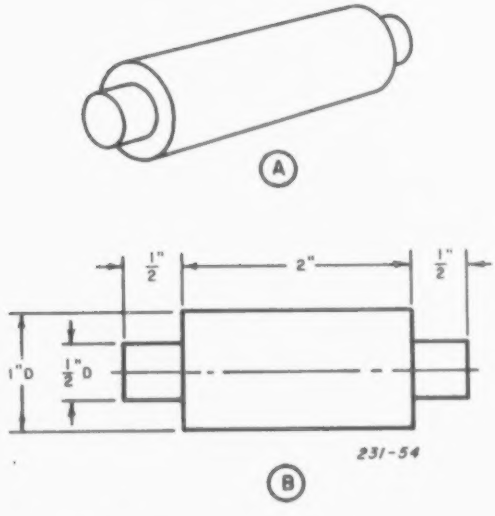


Figure 4-44. One-view drawing of a cylindrical object.

044. State the number of views needed to show the true size and shape of an object to be drawn.

The basic purpose of all multiview projections is to show the true size and shape of the object being represented. Although an object has six possible views, it does not necessarily follow that all six views must be shown to completely describe the object.

How to Determine the Number of Views. The guide for determining the number of views needed to show size and shape of an object is to include only those views which are absolutely necessary. Very thin objects with uniform thickness such as shims, gaskets, and plates need only a single view to be effective, as shown in figure 4-43. Symmetrical objects can often be limited to just one or two views, as shown in figure 4-44. In most cases, the top view of a symmetrical object would be a duplication of the front view.

The front, the top, and the side views are necessary in most other multiview drawings. It is sometimes necessary to show more than the three views or to show the left side view instead of the right side view. Certain types of objects may need only two of any of the three views if the detail is such that it would be virtually impossible to present a true representation any other way.

The practice in drawing is to show all features, hidden or otherwise. Hidden features are shown by short, evenly spaced dashes appearing on at least two of the three views and appearing as a solid on the surface of the third. In laying out a drawing there will be a time when hidden lines, center lines, and story lines (visible lines) will coincide. The essential point of any drawing is the story it's trying to tell, so visible lines are the most important. Visible lines must always take precedence over all other lines; hidden lines are next, then center lines. If a center line coincides with a cutting plane or any other lines that are a part of the story, the line that contributes the most to the readability of the illustration takes precedence. Dimension lines and extension lines should never be placed so that they would coincide with any of the other lines.

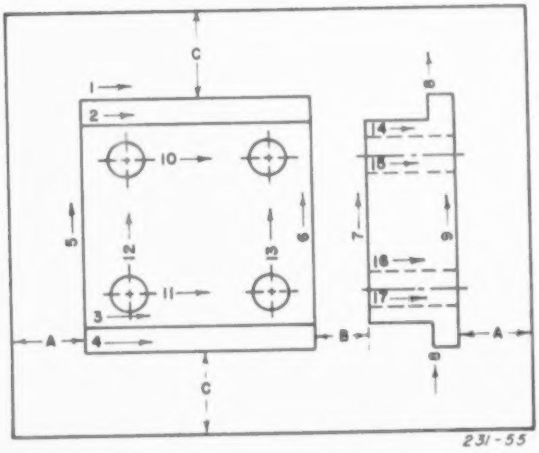


Figure 4-45. Layout for a two-view drawing.

Exercises (044):

1. How many views are possible from one object?

2. How many views are needed to illustrate one object?

3. Which lines take precedence over all other lines?

045. Give three possible solutions to the problem of limited space for a drawing.

Drawing Multiview Illustrations. When drawing multiview illustrations and space is limited, it is permissible to use a partial view when symmetrical objects are being represented. The half view of the drawing should always be the portion nearest to the full view of the drawing. For clarity, where two views of opposite planes can be used to best describe the object, these views need not be complete—provided that, when considered together, they describe the object as one unit. Therefore, only hidden lines immediately behind the surface being viewed need be shown.

Spacing also becomes a problem with objects that are wide. Drawing wide objects in the conventional three-view method will leave large open areas. To avoid this situation, it is permissible to draw the side view to the right of the top view. This appears to give better balance to the page and achieves the same purpose as the conventional three-view method. A rear view can also be drawn as an alternate view; but, to avoid confusion, be sure that alternate views are labeled for identification.

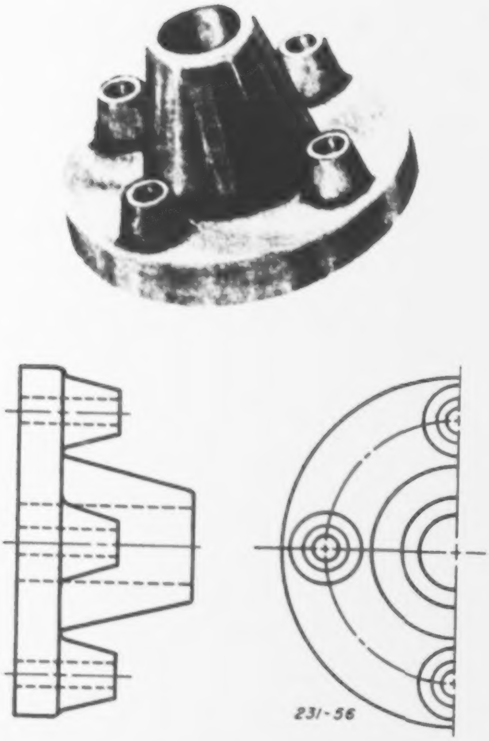


Figure 4-46. Partial view.

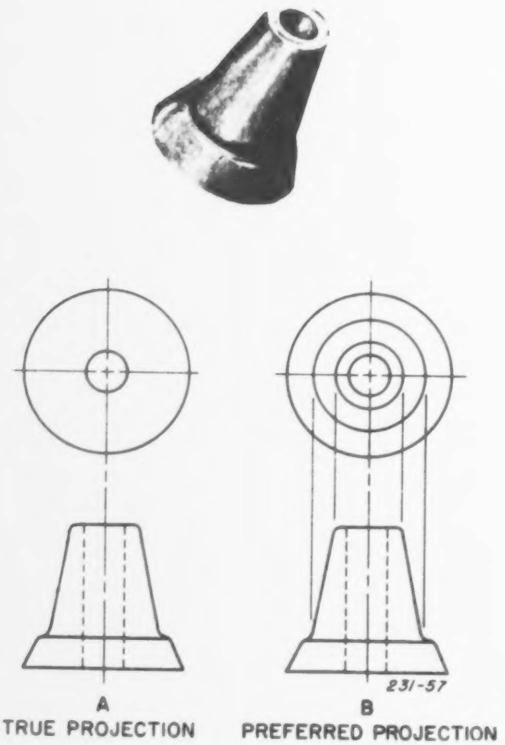

231-57
A
TRUE PROJECTION
B
PREFERRED PROJECTION

Figure 4-47. Top and side views of curved surfaces.

Sometimes when two views are needed to represent an object, you may choose the one to accompany the front view from two or more equally descriptive views. When any one of several possible view combinations will describe the object adequately, you should choose the combination which can be spaced best on the paper. Figure 4-45 illustrates the principle of choosing and arranging views to give a pleasing effect.

In a two-view drawing of a symmetrical object, only a partial view may be needed to describe the object adequately. A break line may be used to limit a partial view. A half-view drawing is shown in figure 4-46. By carefully analyzing the half-view shown in figure 4-46, you should see the principle of this method.

Exercises (045):

1. Where should a half view of a drawing be used?

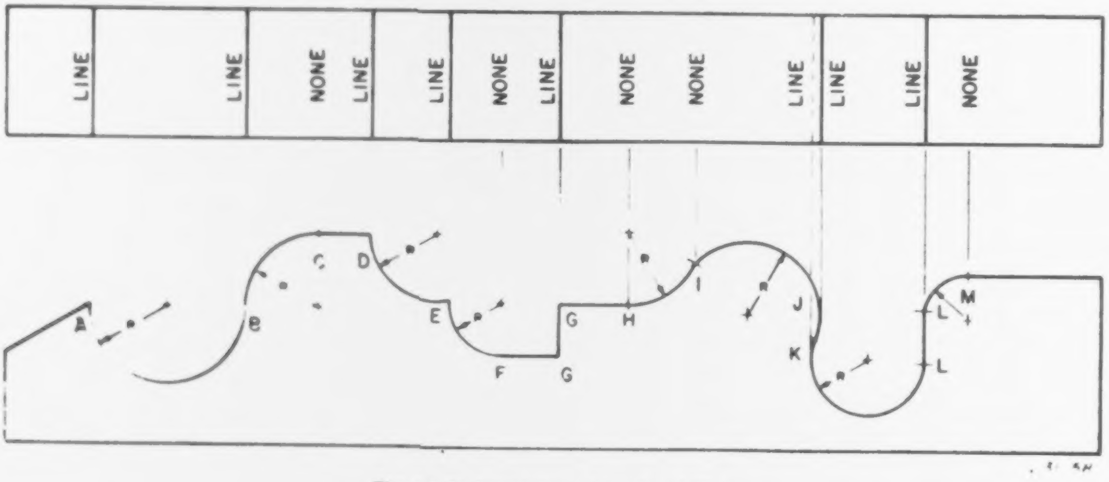

LINE
LINE
NONE
LINE
LINE
NONE
LINE
NONE
NONE
LINE
LINE
LINE
NONE
A
B
C
D
E
F
G
G
H
I
J
K
L
L
M

Figure 4-48. Intersections of rounds and fillets.

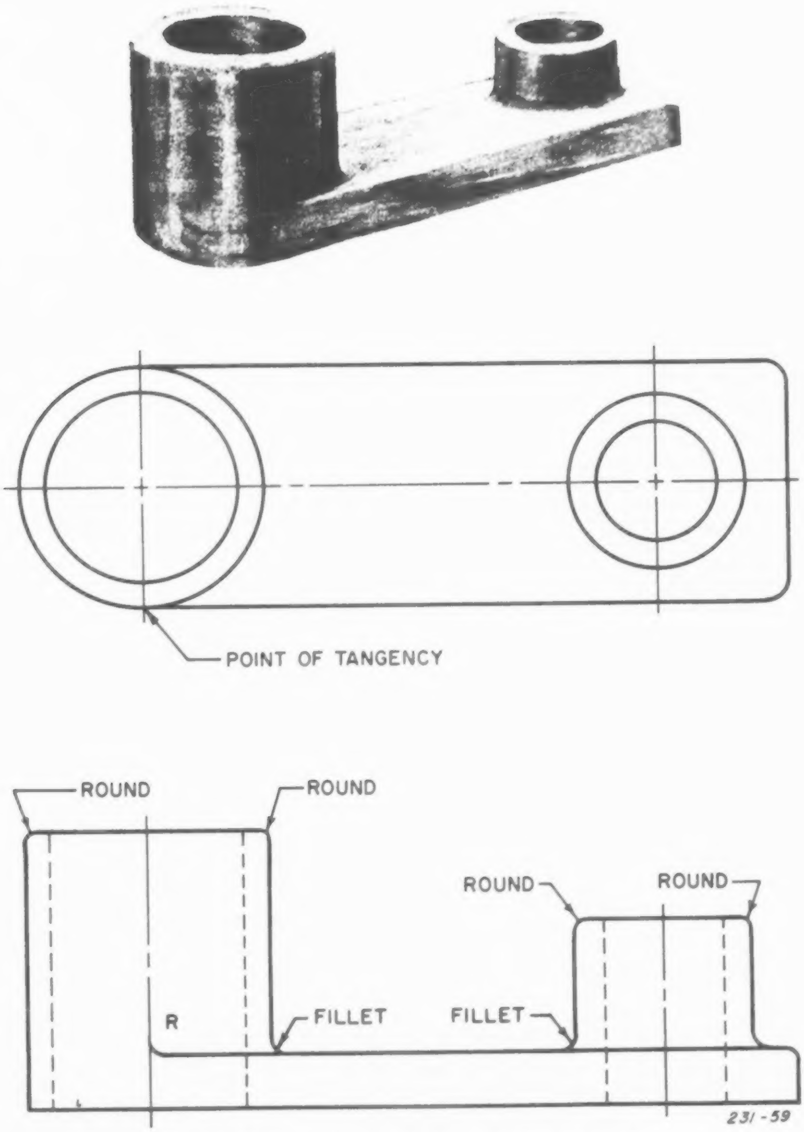


Figure 4-49. Conventional representation of fillets and rounds.

2. What two views are permissible to construct a two-view drawing?

046. Restate given terms from the graphics specialist's vocabulary.

Oblique Surfaces. When a surface is at an acute or obtuse angle to all parallel or principal planes of projection, it is an oblique surface. The true size of an oblique surface will not appear in any of the normal or principal views of a drawing. To show the true shape and size of an oblique surface, a secondary, or auxiliary, view must be drawn. Oblique or auxiliary views are described in more detail later in this volume.

Curved surfaces, curved edges, fillets, and rounds are a vital part of the graphic specialist's vocabulary. He or she should understand how and why these elements apply to the profession. Many objects have curved surfaces and edges tangent to a straight plane. When objects have continuously curved surfaces, as in point B of figure 4-47, that are perpendicular and tangent to each other, they are perpendicular to the plane of projection. When a circle or curve is parallel to the plane of projection, it is drawn as a circle or curve on the parallel plane and as a straight line on the adjacent plane. If the plane of tangency of two curves is at an angle, no line is shown in the plane of projection (see points H and I of fig. 4-48).

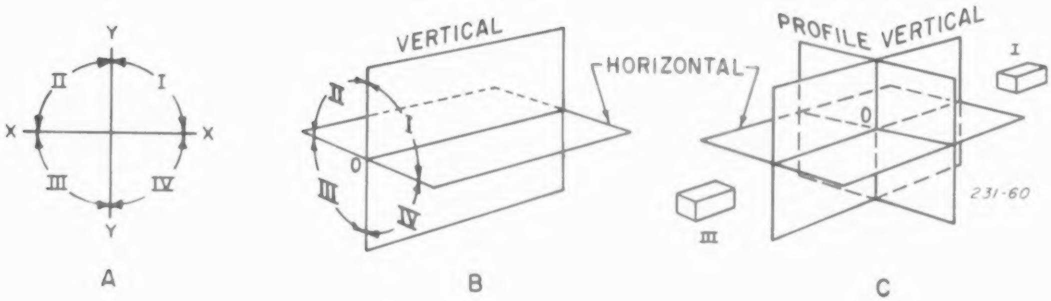

Y
II
I
X
X
III
IV
Y
A
VERTICAL
HORIZONTAL
II
I
O
III
IV
B
PROFILE VERTICAL
I
O
III
231-60
C

Figure 4-50. Planes and quadrants.

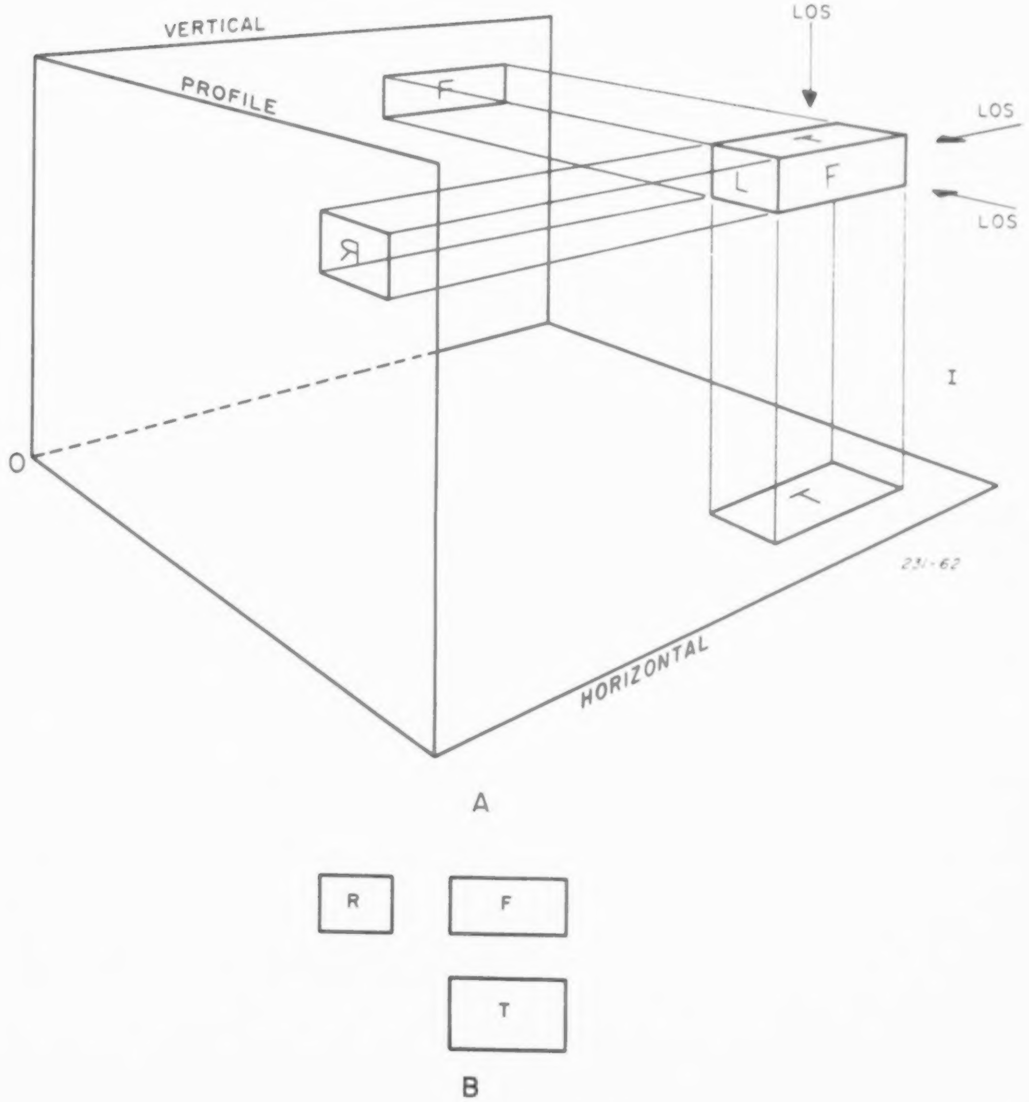

VERTICAL
PROFILE
LOS
F
T
L
F
LOS
LOS
R
I
O
T
231-62
HORIZONTAL
A
R
F
T
B

Figure 4-51. Three essential views.

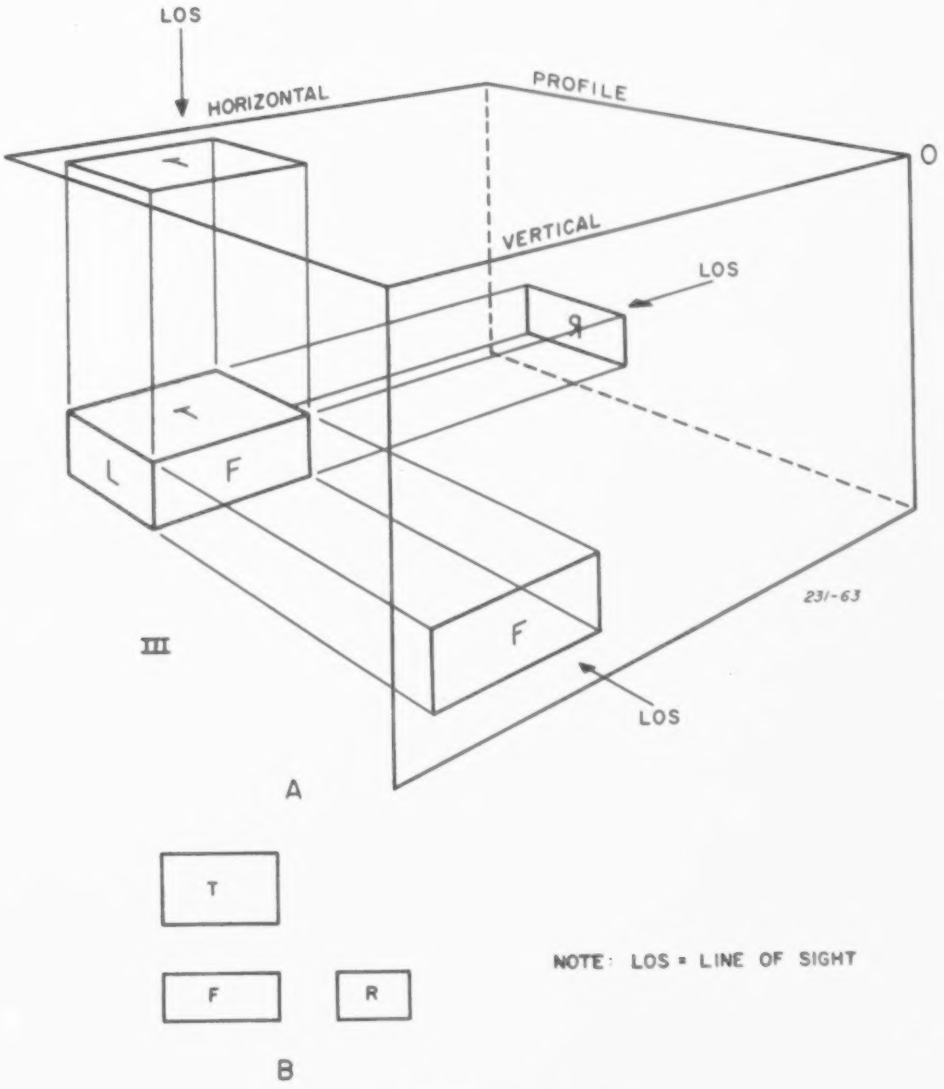


Figure 4-52. Third angle projection.

Fillets and rounds are always shown on drawings to indicate corners of unfinished castings. Since most castings of machine parts and tools are made by pouring molten metal into specially constructed molds, precautions are taken to eliminate sharp corners wherever possible. Besides improving the appearance, rounded corners and edges provide greater strength and ease of handling of the finished product (see fig. 4-49).

If the finished product is to have machined intersecting surfaces, the corners are to be drawn sharp and square. Fillets and rounds are to be designated by note as to the size of the radius. The note should read in this manner, "All fillets and round 1/4 inch radius unless otherwise specified." These notes should be placed near a principal view or in a general area designated for notes. Notice in part A of figure 4-47 that a true projection of a rounded edge has no line to define the intersection of the two different surfaces. But, in the preferred method shown in part B, lines on the projected (top) view represent the rounded edges joining the surface. The added lines show where the surface would intersect if the fillets and round were not there.

Exercises (046):

1. What is a fillet?

2. What is a round?

3. What is an oblique surface?

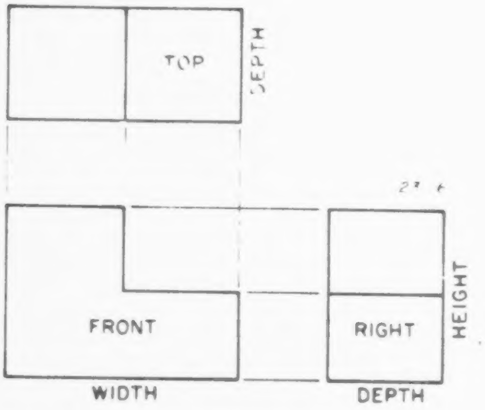


Figure 4-53. Third angle projection.

4. What do fillets and rounds indicate on a drawing?

047. Specify the planes of projection.

Planes of Projection. The three planes used in orthographic projection are the vertical (or frontal) plane, the horizontal plane, and the profile plane. These planes revolve about certain axes to bring the three essential views of a multiview drawing into a single plane. The horizontal plane revolves around the X-axis, and the profile revolves around the Y-axis. The axes are formed by crossing the horizontal and vertical planes, as shown in figure 4-50. The intersection of the horizontal and vertical planes generates four quadrants, known as first, second, third, and fourth angles. An object may be placed in any of the four quadrants and its surfaces projected onto the respective planes.

First angle projection is a system used exclusively in European countries for making drawings. By placing the object in the first quadrant, the viewer looks through the object to the plane of projection. Upon revolving the horizontal and profile planes into the vertical planes, the three essential views assume the position shown in figure 4-51. Notice that the top view is below the front view and that the left side view is to the right of the front view.

Second and fourth angle projections are rarely if ever used in working drawings. When the horizontal and profile planes are revolved into the vertical plane, both the top and front views are superimposed. This overlapping of views tends to restrict the clear visibility of either view.

Third angle projection is the system used in the United States and Canada for orthographic projection. As shown in figure 4-52 in quadrant III, the observer is always on the outside looking in, as compared to the first angle projection where the observer is looking through the object to the image plane. When the horizontal and profile planes are revolved into the vertical plane, the views of the object fall into a logical order. The top is directly above the front views, and the right side view is to the right of the front view (see fig. 4-53).

Exercises (047):

1. What are the image planes or planes of projection?

2. What angle projection do the horizontal and the profile planes fall into in a logical order when revolved into the frontal plane?

048. Name and define the three types of axonometric projections.

Axonometric Projection. Axonometric projection is an orthographic pictorial projection of an object whose three major surfaces are angles to a single plane of projection. As with other pictorial drawings, this type of projection gives us only an overall description of the external surfaces of an object and a three-dimensional concept of its shape, form, and mass. Since it is often necessary to show the natural appearance of the whole object, you can see the necessity for representing it pictorially.

Objects having very complicated outlines can be represented by means of orthographic multiview drawings. However, to read some multiview drawings, a person must have a high degree of skill and a constructive imagination. To insure that the person gets the correct impression from a drawing, a pictorial (axonometric or perspective) drawing is often used instead of, or in conjunction with, an orthographic drawing. Many technical illustrations, design and patent-office drawings, etc., are made as one-plane pictorial projections.

Since an object can be placed in an infinite number of positions in relation to the plane of projection, it is possible to make an infinite number of axonometric projections of the same object.

The inclined position of the object with respect to the plane of projection is the distinguishing feature of axonometric projection as compared to multiview projection. Since the principal edges and surfaces of the object are inclined to the plane of projection, the length of the lines, the size of the angles, and the general projections of the object vary with the infinite number of possible positions in which the object may be placed with respect to the plane of projection. Projections from these infinite numbers of possible positions may be classified into three general types of axonometric projection—isometric, dimetric, and trimetric.

Types of Axonometric Projections. As shown in figure 4-54, a projection of an object whose three visible surfaces are at equal angles to the plane of projection is classified as an isometric projection. A projection of an object which has two of its three visible surfaces at equal angles to the planes of projection is called a dimetric projection. When all three surfaces are at unequal angles to the plane of projection, the projection is called a trimetric projection.

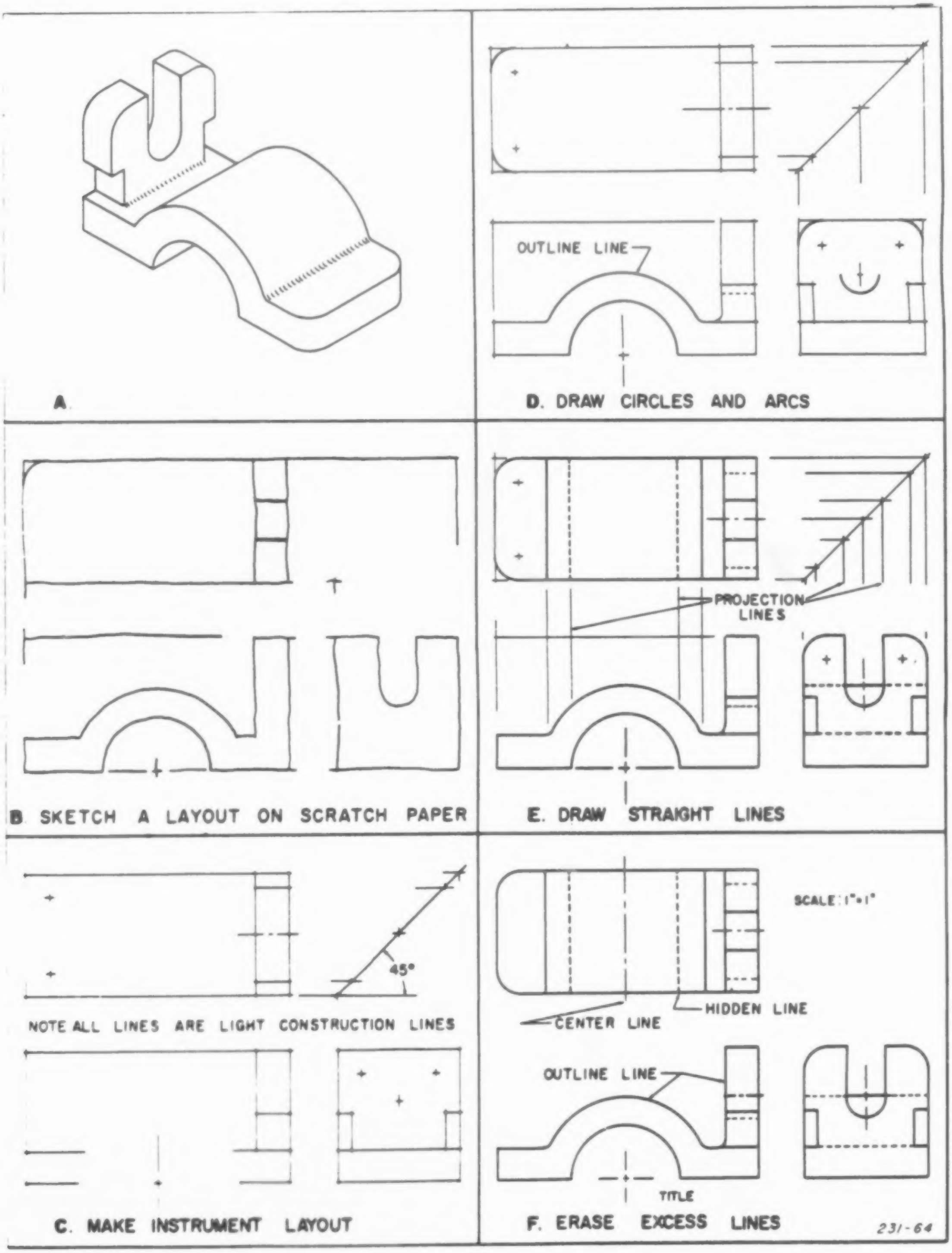

A.
D. DRAW CIRCLES AND ARCS
OUTLINE LINE
B. SKETCH A LAYOUT ON SCRATCH PAPER
PROJECTION LINES
E. DRAW STRAIGHT LINES
45°
NOTE ALL LINES ARE LIGHT CONSTRUCTION LINES
C. MAKE INSTRUMENT LAYOUT
SCALE: 1"=1"
CENTER LINE
HIDDEN LINE
OUTLINE LINE
TITLE
F. ERASE EXCESS LINES
231-64

Figure 4-54. Steps in making a drawing.

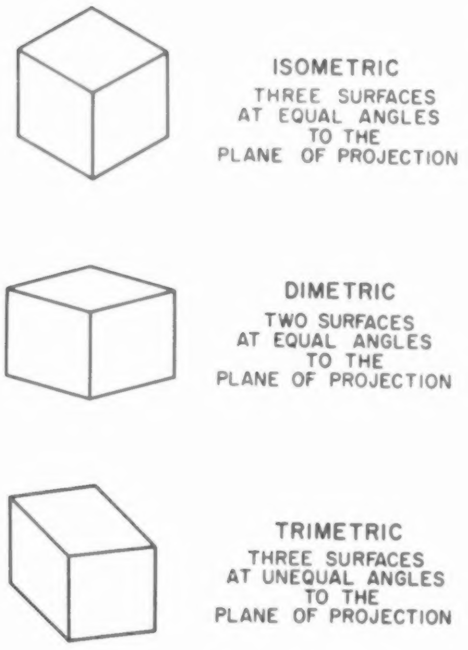

ISOMETRIC
THREE SURFACES AT EQUAL ANGLES TO THE PLANE OF PROJECTION
DIMETRIC
TWO SURFACES AT EQUAL ANGLES TO THE PLANE OF PROJECTION
TRIMETRIC
THREE SURFACES AT UNEQUAL ANGLES TO THE PLANE OF PROJECTION

Figure 4-55. Types of axonometric projection.

Figure 4-55 shows the projection of a cube in the three different types of axonometric projection; the edges of the cube are foreshortened, since they are inclined to the plane of projection. The degree of foreshortening of any line depends on its angle with the plane of projection. The foreshortening increases as the angle becomes greater.

It is customary to consider the three edges of the cube which meet at the corner nearest the observer as the axonometric axes. If the degree of foreshortening of these axes is determined, scales can be easily constructed for measuring along these edges or along any other edges parallel to them.

Since the principles of the three different types of axonometric projections differ only with respect to the angles of the axes and the degree of foreshortening, we will limit our discussion of axonometric projection to isometric projection. The same or similar methods of construction can be used in dimetric and trimetric projection.

Principles of isometric projection. To produce an isometric projection, the object must be placed so that its principle edges make equal angles with the plane of projection (frontal plane). This means that from its normal orthographic position the object must be rotated 45° about its vertical axis and then tilted forward around its horizontal axis until its principal edges make equal angles with the plane of projection.

Figure 4-56 shows how an isometric is projected. Refer to this figure as you read the procedure which follows. First, draw the top view showing the cube rotated 45° from the normal multiview position. This places the two lateral faces of the cube at an angle of 45° to the plane of projection. Next, project the front and elevation views from this top view. Transfer the elevation view so that the line AE representing the diagonal axis of the cube is perpendicular to the plane of projection. Line AE is now a horizontal line. Locate points A, B, C, D, and F on your drawing paper by projecting them from the orthographic front view and the repositioned elevation view. Complete the isometric by drawing lines between the appropriate points.

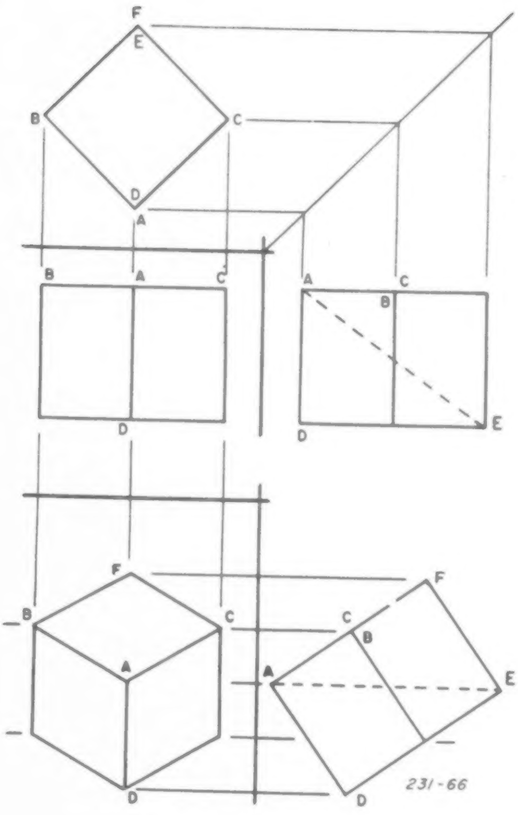


Figure 4-56. Isometric projection.

Notice in figure 4-56 that the three edges AB, AC, and AD of the isometric are foreshortened equally. If you measure these lines and compare them with the dimensions in the original cube, you will find that they are about 82 percent of true length. Also notice that the isometric axes (in this case AB, AC, and AD) make 120° angles with each other. All lines parallel to these isometric axes are called isometric lines. All planes parallel to the faces of the cube are called isometric planes. Lines and planes which do not fulfill these conditions are called nonisometric.

Foreshortening. A correct isometric view may be drawn by actual projection by foreshortening all isometric distances to approximately 82 percent of true size when the view is drawn. A three-quarter size scale (3/4" = 1") may be used to approximate the correct measurements for foreshortening isometric lines. When an isometric view is prepared by using a normal scale, the resulting representation is called an isometric drawing. An isometric drawing is similar to an isometric projection, except for size; the drawing is not foreshortened. Because isometric drawings are made full size or full scale, it is standard practice to make isometric

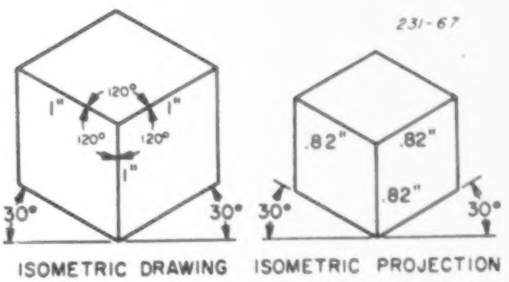


Figure 4-57. Isometric views compared.

drawings instead of true isometric projections. Figure 4-57 shows the comparison between an isometric drawing and an isometric projection. When the axes measurements are drawn full size using a regular scale, the isometric drawing is about 22.5 percent larger than the true projection. It is much more practical to use an isometric drawing than it is to use an isometric projection, since measurements can be made much more easily. However, when a projection is required, it is easier to construct the isometric by isometric measurements than it is by the actual projection method. The following is a method you use to construct an isometric scale if the correct scale is not available to you.

Isometric scale. When a drawing is made with an isometric scale, the isometric dimensions of the object are the same as if it were actually projected on a plane of projection. As we stated previously, an isometric scale is a three-quarter size scale. Its dimensions are approximately 82 percent of a regular scale. The following procedure for constructing a scale is illustrated by figure 4-58.

(1) Draw a horizontal line.

(2) Draw the 45° line to the horizontal line.

(3) Using your regular scale, mark off the units and intermediate divisions on the 45° line.

(4) Draw lines perpendicular to the horizontal line to each division mark.

(5) Draw the 30° line.

(6) Place a piece of paper, cardboard, or some similar material along the 30° line as shown and mark the isometric divisions on the material.

During the discussion which follows on making an isometric drawing by the box method, no numerical dimensions (only literal) are used. If numerical dimensions were given, they could be either isometric scale or regular scale units—the method of drawing would be the same.

Isometric drawing. Remember, the only difference between an isometric drawing and an isometric projection is the scale used. Refer again to figure 4-57. Note that the isometric projection was "drawn" with an isometric scale, and the drawing with a regular scale. Isometric drawings are built on a skeleton of three lines representing the three principal edges or axes of a cube. All measurements are made along these axes or lines parallel to them (isometric lines). The location of nonisometric lines and other points must be found by coordinate measurements which are made parallel to the isometric axes. (Only isometric lines and planes are

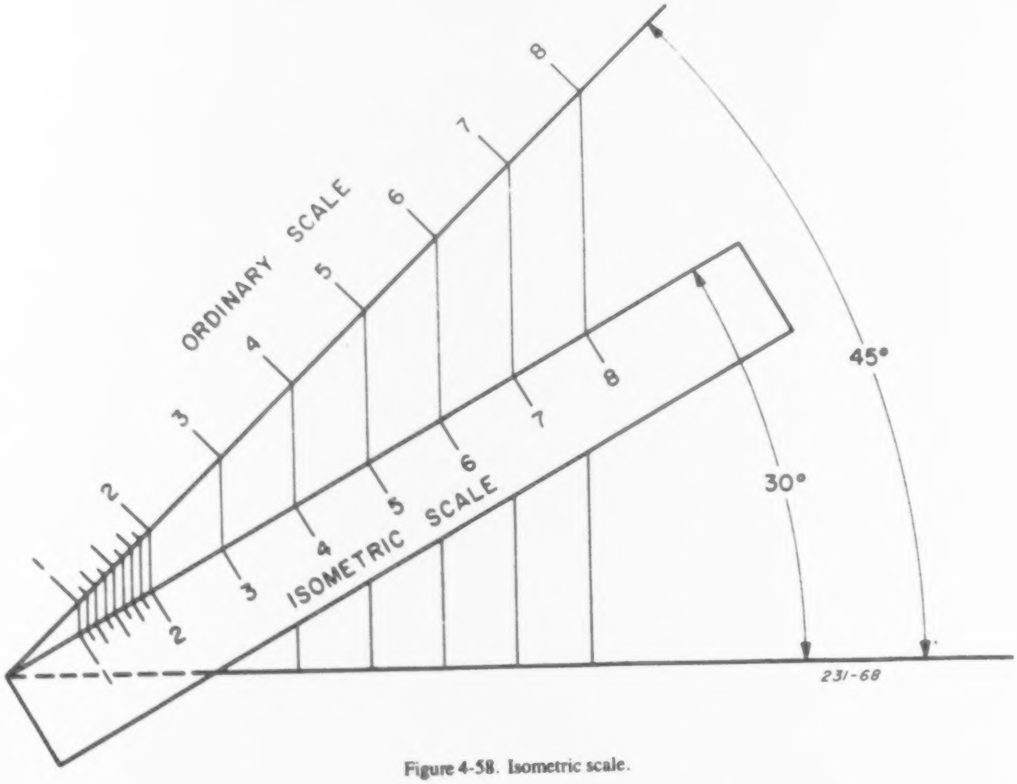


Figure 4-58. Isometric scale.

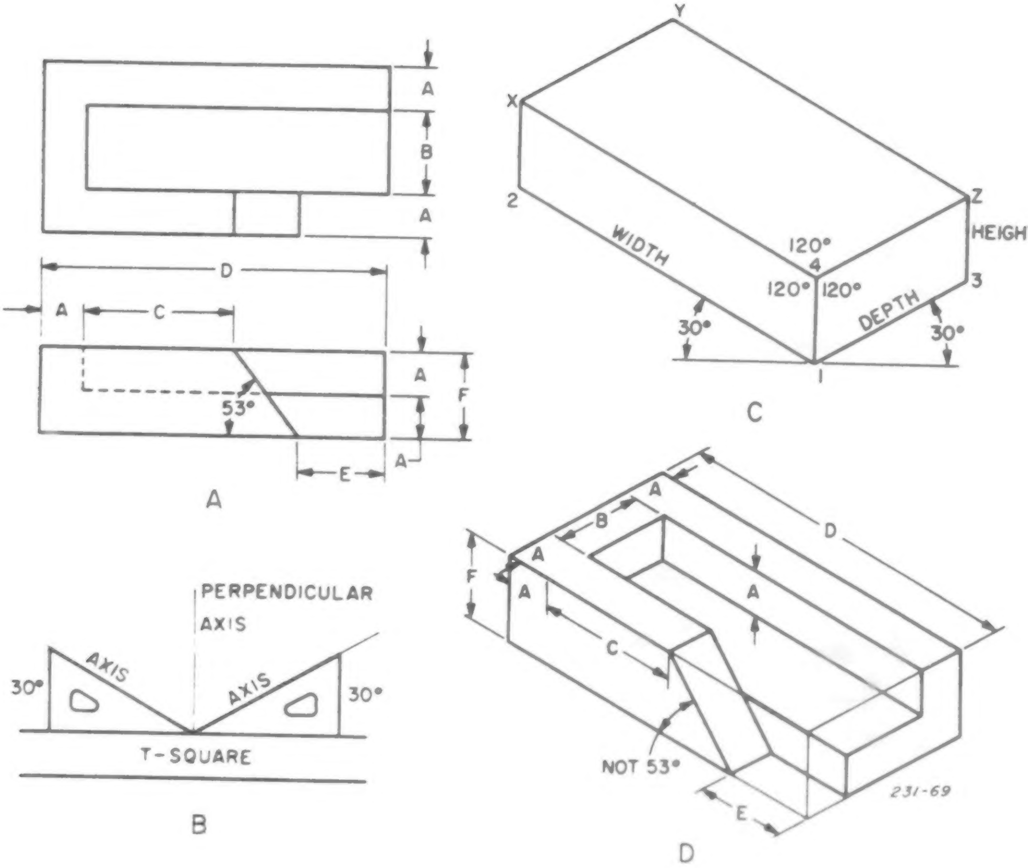


Figure 4-59. Box method for isometric drawing.

shown in true length in isometric drawing and projection.) An easy way to represent an object in an isometric drawing is by the box construction method. First, we'll discuss the construction of an isometric box and follow with inserting the object in it.

Box construction. The procedure which follows shows the method for drawing an isometric rectangular box whose sides coincide with the main faces of the object—height, width, and depth. Refer to figure 4-59 as you study the following procedure.

a. From a point which represents the lower front corner (1) of the box, draw the three light construction lines as shown in part B of figure 4-59. These lines, 1-2, 1-4, and 1-3, are the three major axes for constructing the isometric box shown in part C.

b. From this lower front corner (see part C), start building the inclosing box by transferring the height, width, and depth dimensions from the orthographic (multiview) drawing of part A. After the corners (1 through 4) have been established, complete the box by drawing the parallel edges (isometric lines) as shown in the illustration. These lines establish corners X, Y, and Z.

c. The box can also be completed in the following manner. Notice that at the top front corner (4) of the box, the axes make 120° angles with each other. Because the inclosing box is made up of isometric lines, you can complete it by using your T-square and 30°- 60° triangle and architect scale or dividers. Now, let's draw the object by means of the isometric box.

Drawing the object. The object drawn by means of the box is shown in part D of figure 4-59. Notice how measurements from part A set off on the corresponding isometric edges. Be sure to follow the rule of making all measurements on only the isometric axes or isometric lines. As you study these illustrations, use your dividers to compare the measurements. These measurements coincide with those in the multiview drawing because this is an isometric drawing, not a projection.

Now use the coordinate method to draw nonisometric lines. This is done by making measurements along isometric lines to locate the end points of the nonisometric lines. An example of a nonisometric line located in the way is the front edge of the oblique plane in the isometric view. This oblique edge is located on the isometric view by first marking off distance A + C (see part A) on the upper left edge of the left front face of the box. This establishes one end point of the oblique edge. The other end point is located by marking distance D-E off on the lower part of the base line of the same face. Remember that, in drawing both isometric and

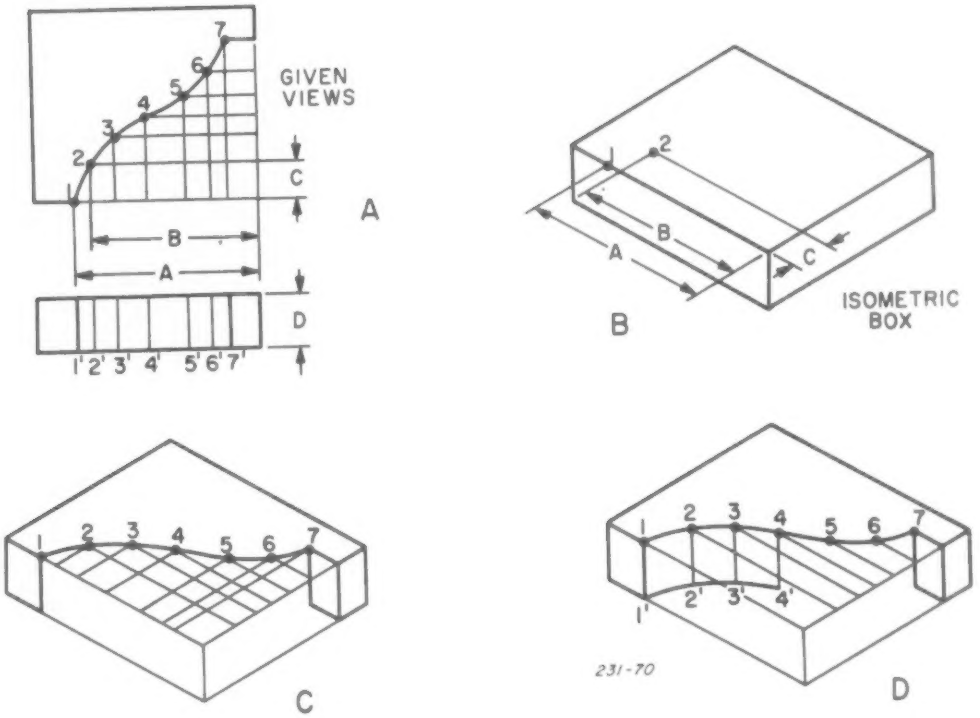


Figure 4-60. Curves in isometric projection.

nonisometric lines, all lines parallel with each other in the object are represented by parallel lines on an isometric view. Furthermore, notice that the only dimensions which do not coincide with the multiview are those of the oblique portion and the angle. The size of an angle is changed when it is in an isometric drawing.

After the drawing is finished, erase the light construction lines. These lines are indicated in part D of figure 4-59.

NOTE: In isometric drawing, do not show invisible edges unless they are necessary for a clear description of the part. It is common practice in all pictorial drawing to omit all invisible lines, provided they are not needed to explain some hidden feature. Also, you should avoid excessive use of center lines, to show the axes of symmetrical parts. Use dimension lines to indicate dimensions.

Curves in isometric. The offset method of measuring is widely used in the drawing of curved lines. This method consists of locating points through which the desired curve is drawn. Figure 4-60 shows how to draw noncircular curves from points plotted by offset measurements. The curves in solid figures usually appear in pairs as parallel curved edges of the object. To simplify your drawing, draw one curve by plotting the points and then draw isometric lines from the points. Find the remaining parallel curve by stepping off the distance along corresponding isometric lines. Here's how this is done.

Figure 4-60 consists of four parts which show the steps used to make an isometric drawing of an object containing a curved surface. First, draw the orthographic top and front views of the object as shown in part A. In the top view, select at random along the curve any number of desired points, such as 2 through 6. (Points 1 and 7, being the ends of the curve, are established points.) Use enough points to fix accurately the path of the curve. Draw vertical and horizontal offset grid lines from these points.

Draw the isometric box as shown in part B of figure 4-60. Lay off along isometric lines the dimensional measurement A and the offset measurements B and C from the top view to locate points 1 and 2 on the curve in the isometric box. Locate the remaining points by using the same offset method. This step is shown in part C of the figure and represents a continuation of step B. After locating all points, sketch a light freehand curve through the points as shown in the illustration.

Notice in the front view of the multiview projection that points 1' through 7' are established by projection from the top view. Locate these points in the isometric (see part D of fig. 4-60) by drawing vertical lines downward from points 1 through 7, making all lines equal to the dimension D shown in the orthographic front view. Sketch a light freehand curve through the ends of these lines (points 1' through 7'). Complete the curved surface by drawing the finished curve, using an irregular curve as a guide.

Circles in isometric. When a circle lies in a plane which is not parallel with the plane of projection as in isometric drawings, the circle projects as a true ellipse. However, an approximate ellipse is accurate enough for nearly all isometric drawings. (Ellipses were presented earlier.) An approximate view of a circle can be drawn by the four-center

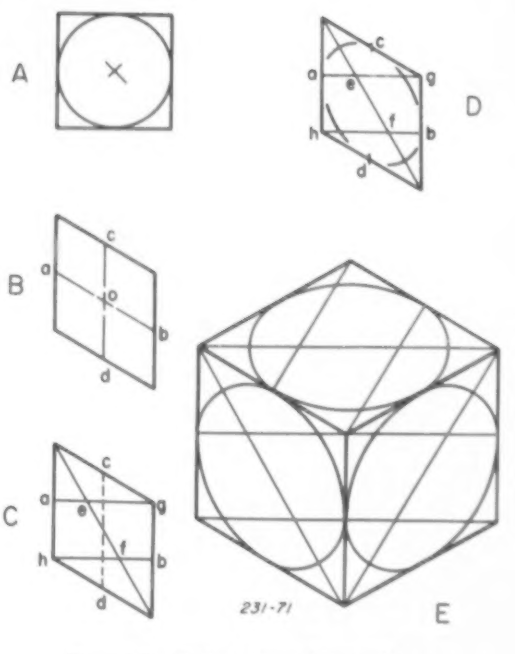


Figure 4-61. Circles in isometric projection.

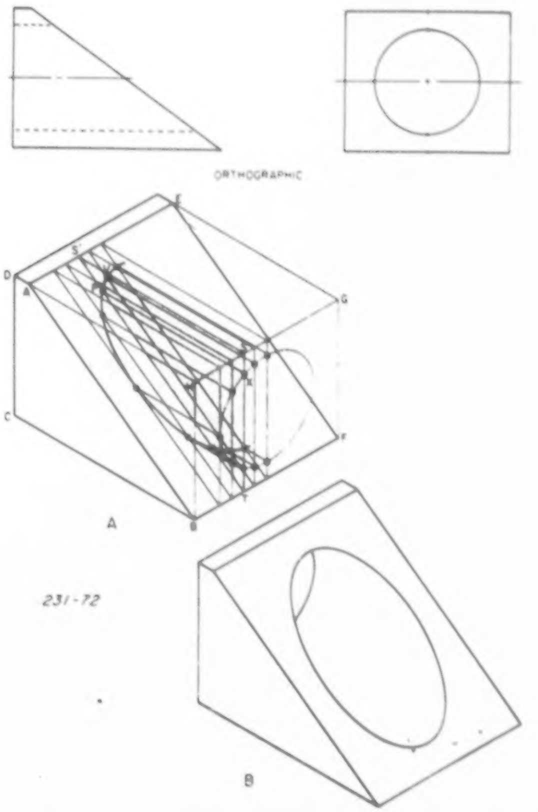


Figure 4-62. Isometric circle on nonisometric plane.

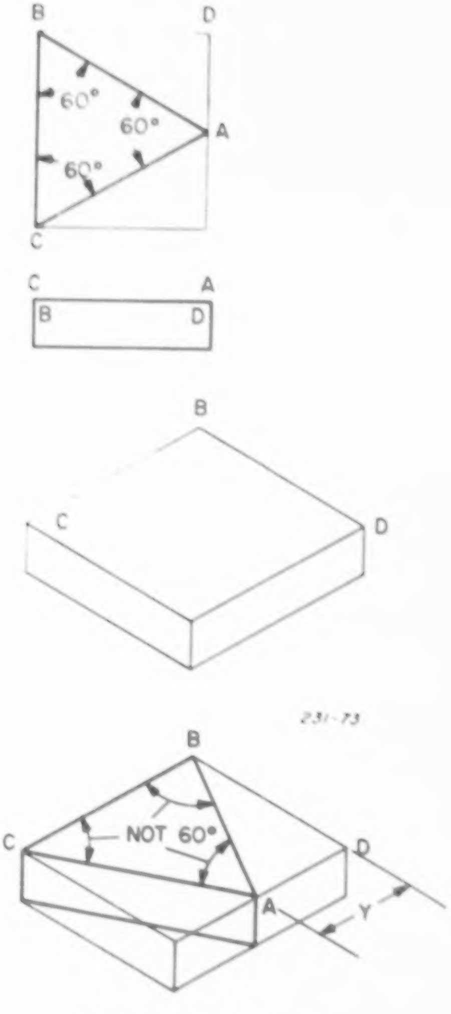


Figure 4-63. Angle in isometric.

method. This construction can be used only for a circle which lies in an isometric plane.

Part A of figure 4-61 shows a circle inscribed in a square which is parallel to the image plane. To draw this circle in isometric form, the first step is the construction of an isometric square with sides equal to the diameter of the circle, the same dimensions as in part A. Part B of figure 4-61 shows the construction of the isometric square. You can see that it is drawn by means of the 30° - 60° triangle using the principle of parallel lines. Now, let's inscribe the ellipse within this isometric square by means of the four-center method.

Locate the midpoints, a, b, c, and d, of each side of the square, and then connect points ag and bh (see part C). Next, draw the long diagonal. This diagonal makes an angle of 60° with the horizontal. The points of intersection, e and f, of the lines ag, bh, and the long diagonal are centers for the two short arcs. The centers for the two long arcs are points g and h. Now draw the ellipse with a compass (see part D).

Using point e as center and radius ae, draw arc ac. Similarly, using point f as center and radius bf (same as ae), draw arc bd. Now we have the two short arcs. The long arcs

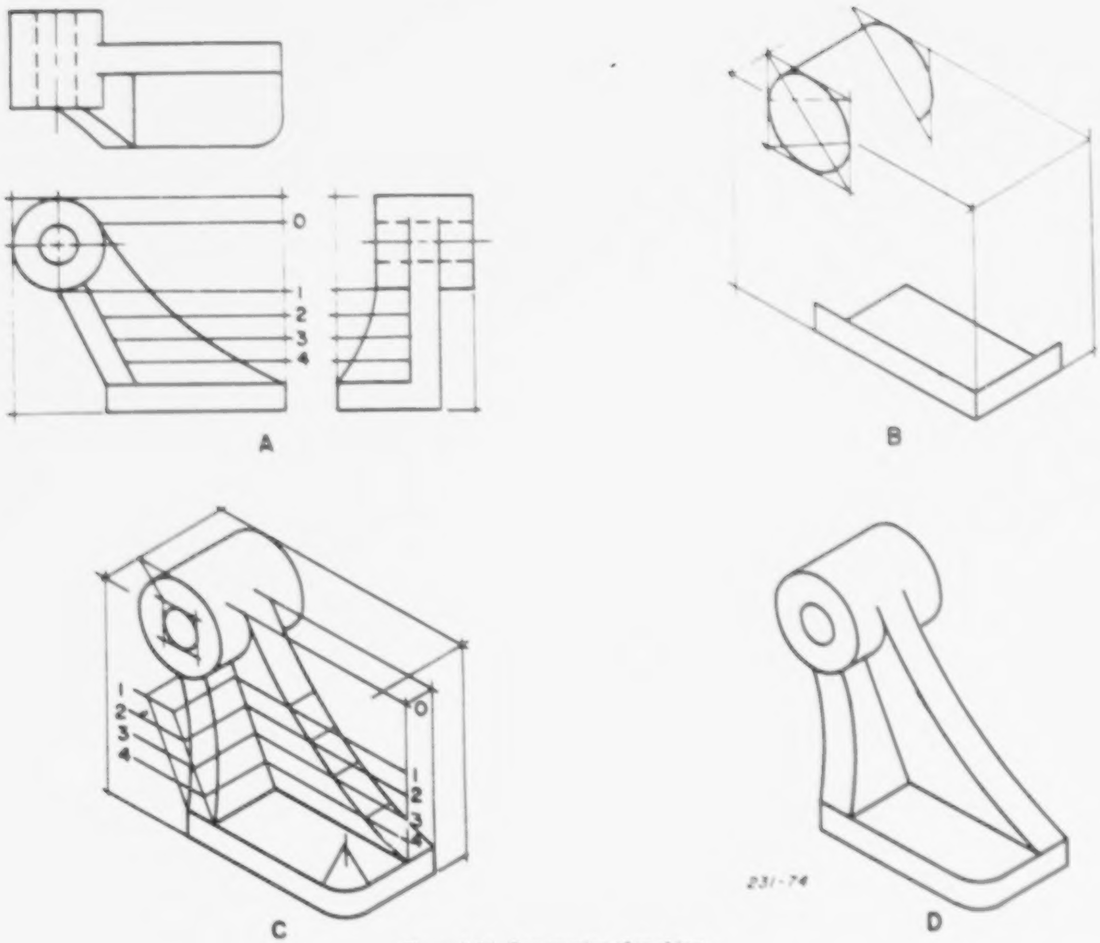


Figure 4-64. Construction of an object.

are drawn in the same way. Using point g as center and radius ag, draw arc ad; and then using point h as center and radius hb, draw arc cb. Thus, the four-center ellipse is completed. The four arcs shown in part D were purposely not connected to show the four separate arcs.

Part E of figure 4-61 shows the construction of the four-center ellipse upon the three visible faces of a cube. Notice that two of the long diagonals are 60° to the horizontal, the other is horizontal, and all three are of equal length. Hence, the entire construction can be made with a T-square and 30° - 60° triangle. Observe this figure closely, and you will see that each ellipse is constructed by the four-center method in the way we described earlier. Use your compass or dividers and locate the centers and radii of the arcs on the faces by the method just explained.

Isometric circle on nonisometric plane. Circles and circular arcs in nonisometric planes are plotted by using the offset or coordinate method. Figure 4-62 illustrates how this construction is made. Observe this illustration carefully as you study the following procedures.

a. To begin, draw an isometric box around the object according to the orthographic dimensions (see part A). Notice that the object is drawn without the ellipse on the inclined face.

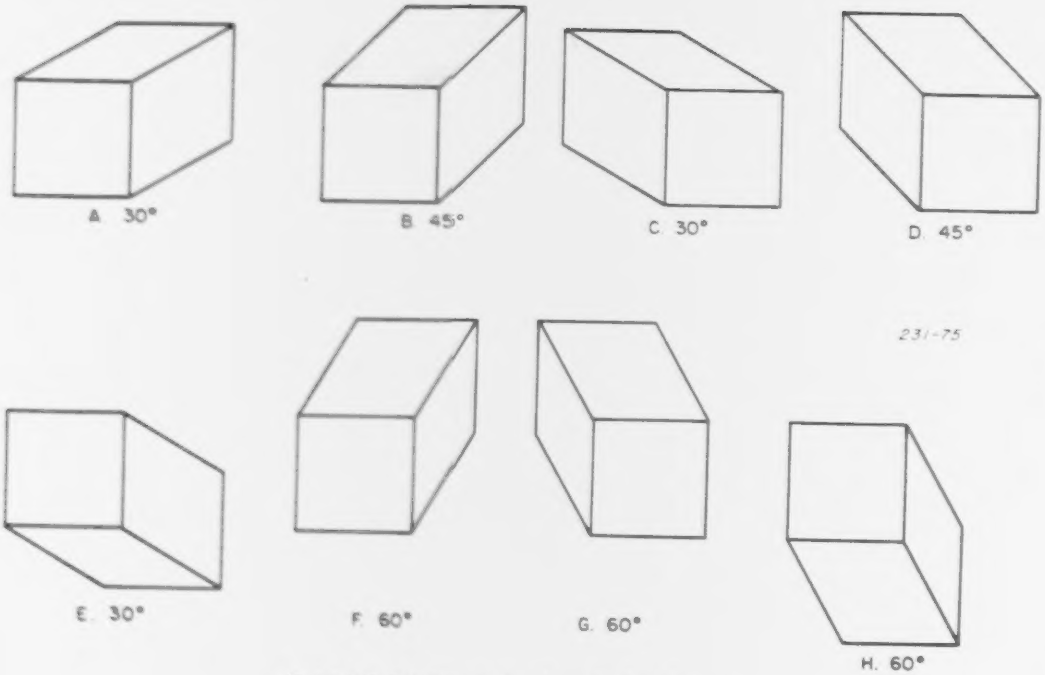
b. Next, draw an ellipse on face BHGT using the orthographic dimensions to construct it and space it correctly. The isometric circle (ellipse) may be constructed by means of the four-center method.

c. Construct a series of planes parallel to face ADCB. (Five planes are shown in the figure.) One edge of each plane is represented by a line parallel with face AEGH and the other edge by a line parallel with face BHFG. For instance, notice edges S'S and ST, which represent one of the planes.

d. Draw diagonal lines (parallel with AB) along the sloping surface to complete the limits of the constructed planes. For instance, S'T is the diagonal for one particular plane. These diagonal lines lie on the sloping surface.

e. At points where the planes cut the isometric circle, draw isometric projection lines parallel to AH to intersect corresponding sloping lines. The point at which a projection line intersects a sloping line is a point on the required ellipse. For example, note that line ST cuts sloping line S'T at point P. Thus, point P is an established point on the required ellipse.

Other points are established in exactly the same manner. You can see the more planes that are drawn, the greater the number of points that can be established; hence, a smoother


A. 30° B. 45° C. 30° D. 45°

E. 30° F. 60° G. 60° H. 60°

Figure 4-65. Variations in views by angle of receding axes.

ellipse can be drawn through the points by means of an irregular curve.

Angles in isometric. Recall that an angle projects true size only when the plane of the angle is parallel to the plane of projection. Since in isometric the surfaces of the object are inclined to the plane of projection, the angles are not projected in true size. Any angle may project larger or smaller than true size, depending upon its position. Hence, an angle must be drawn by linear measurements along isometric lines, not drawn by the actual degrees of the angle.

Figure 4-63 shows the isometric drawing of a triangular object from the multiview. The inclosing isometric box is constructed by transferring dimensions from the multiview. The vertex of the equilateral triangular surface is found by locating point A by measurement (from the multiview) along an isometric line, as shown. Of course, point A is midpoint because the triangle is equilateral. Notice that none of the angles are 60° in the isometric. To verify this fact, measure each angle in the isometric with your protractor.

Construction of an object containing curves. Figure 4-64 shows the steps in constructing an isometric drawing of an object which is composed of a cylinder and curved surfaces. Study the steps shown in the illustration. Use your dividers to compare measurements, and you should see the principles of this particular method.

First box in the object as shown in part A of figure 4-64. Then mark off points on the object and draw horizontal lines from these points to the box. Using the dimensions of the orthographic views, draw an isometric box as shown in part B. Then draw the cylindrical portion and the base of the object. Next, as shown in part C, lay out the isometric lines representing the horizontal lines drawn on the orthographic views. Use these lines to locate the two curves and webs. Complete this step by using your irregular curve to draw the two curves through the points as shown. Part D shows the finished drawing.

Exercises (048):

1. What does the term *isometric* mean?

2. For isometric projections, the object must be rotated how many degrees around its horizontal and vertical axes?

3. In all axonometric projections, the sum of the angles formed by the three axes is ________.

4. In which type of axonometric projection are the three angles formed by the axes unequal?

5. What are the three types of axonometric projections?

049. Define cavalier and cabinet oblique projection drawings.

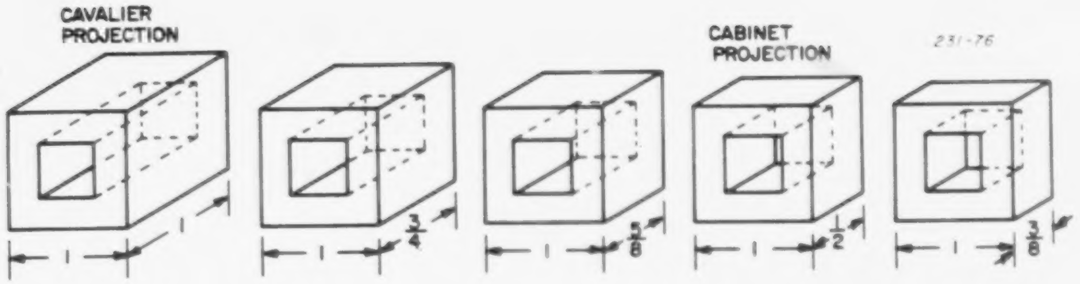


Figure 4-66. Changes in appearance by foreshortening.

Oblique Projections. The construction methods for isometric and oblique drawing are similar. To simplify an oblique construction, choose as the front face the one showing the most description of the object and place it parallel to the image plane. After this, the drawing is made by the *box construction* method—similar to isometric. Other steps in oblique drawing include skeleton construction method, circle and arcs not parallel with the image plane, and angles. We'll cover these in order. But first we'll discuss foreshortening of receding lines and the construction of oblique drawing, based upon cavalier and cabinet.

Cavalier and Cabinet Types. Following are the definitions for these two particular types of oblique projections (see fig. 4-65).

(1) An oblique drawing is called a cavalier when the receding lines are true length. (Projectors at an angle of 45° with the image plane.)

(2) An oblique drawing is called a cabinet when the receding lines are drawn half of true length.

A projection which does not fall into either category is usually called just an oblique projection. Since in the oblique projections shown thus far the projectors have been at an angle of 45° with the image plane and the projected lines in a cabinet drawing, the receding lines are half of the true length. Theoretically, this means that the projectors make an angle of about 63.5° with the image plane; consequently, the lengths of the receding lines are foreshortened to half of true length. However, we'll not cover the actual mathematics, since the desired length of receding edges may be drawn by measurement.

Figure 4-66 shows the difference in the apparent shape of a cube that results by foreshortening the receding lines. Notice that the receding lines of the cabinet drawing are half the true length of the cavalier. Often a cabinet drawing is

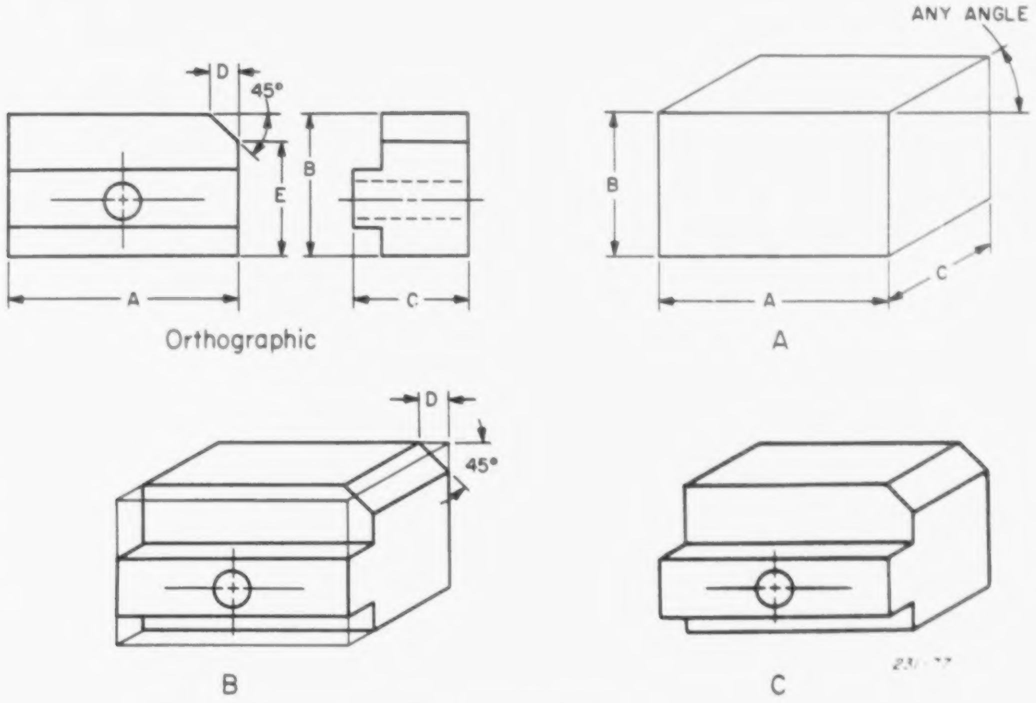


Figure 4-67. Box construction method.

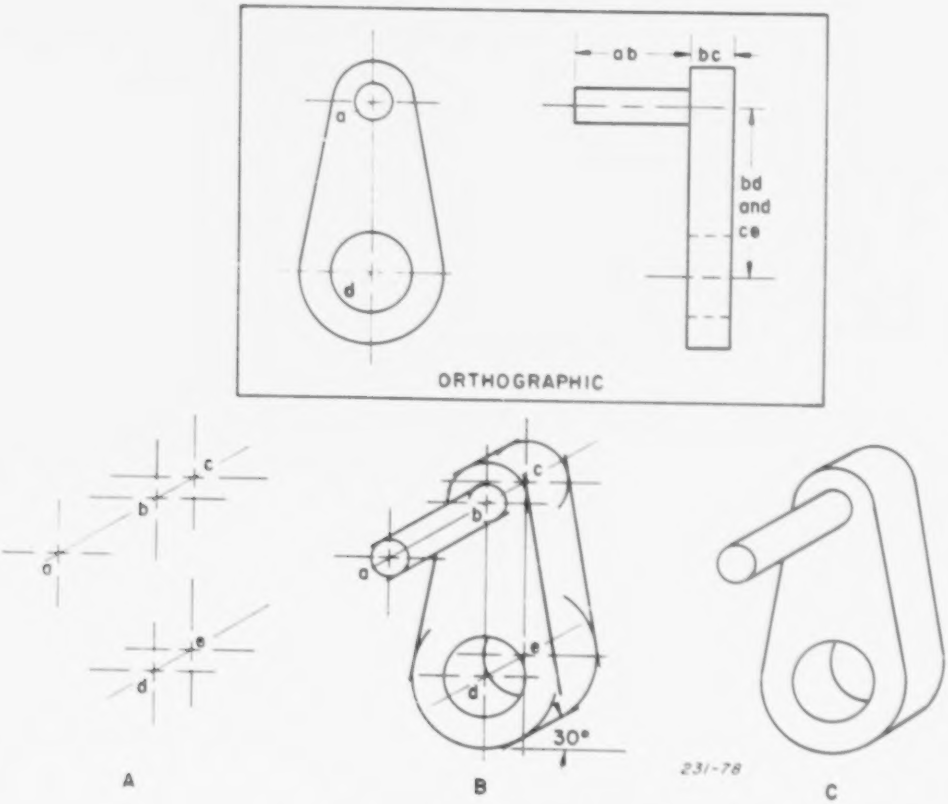


Figure 4-68. Skeleton construction.

preferred to a cavalier, depending upon the dimensions of the object. As in the case of the cube, the cabinet projection appears less out of proportion than the cavalier.

Box construction method. The steps for making an oblique drawing from the orthographic views are shown in figure 4-67. Refer to the figure as you check the following steps. You'll see that the principles of the box method in oblique and isometric drawing are identical.

a. As shown in part A, construct the box whose dimensions coincide with those in the orthographic drawing. In this case, the angle chosen between the receding lines and the horizontal is 30°. However, this angle may be 45° - 60° or any number of degrees, as noted in the figure. Note that dimensions A, B, and C are the same as in the orthographic drawing. Since dimension C is true length, the drawing is a cavalier. (Measure the dimensions with your dividers.) Observe that the box is constructed by using parallel lines, as in isometric.

b. As shown in part B, lay out the various shapes in detail in accordance with the orthographic drawing. Notice that the 45° sloping surface may be drawn by using dimensions D and E.

c. Make all outlines heavy as shown in part C. Then erase all construction lines.

The box method of constructing a cabinet drawing is the same as that of the cavalier, except that the receding lines are foreshortened by measurement to one half of true length.

Skeleton construction method. If the curved outlines of an object lie in planes that are parallel to the image plane, it is not difficult to make an oblique drawing on a center-line skeleton.

Often objects adaptable to oblique representation consist of cylindrical shapes built upon axes or center lines. In such cases, the oblique drawing is usually constructed upon the projected center line. This method is known as skeleton construction.

Figure 4-68 illustrates the procedure in making an oblique drawing of an object, which is composed of cylindrical shapes, from the orthographic views. Now let's discuss this construction in a logical sequence.

a. First, construct the *center-line skeleton* as shown in part A of the illustration using the following steps.

(1) Draw the receding axis abc of sufficient length at the desired angle with the horizontal. (In this case, 30° is used.)

(2) At points a, b, and c on this receding axis, draw the horizontal and vertical center lines to establish centers of the corresponding circular surfaces. Observe that distance ab in part A equals distance ab in the orthographic side view and, likewise, distance bc equals the depth bc in the side view.

(3) Draw perpendiculars downward from points b and c.

(4) Using the distance between the centers of the circular surfaces in the front orthographic view—or the corresponding distances in the side view—locate points d and e on the perpendiculars.

(5) Through points d and e, draw receding axis de, which

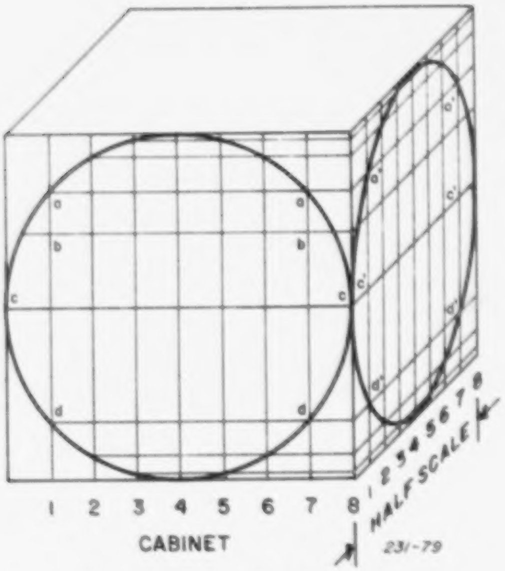


Figure 4-69. Foreshortening an ellipse.

is parallel to receding axis abc. Notice that distances bc and de on the receding axes are equal and are the same as depth bc in the orthographic side view. Thus, we've established the centers of the circular surfaces.

b. Part B of figure 4-68 shows the method of constructing on the circular surfaces and the corresponding outlines. The steps are as follows:

(1) Using points a and b as centers, draw the two circles to correspond in diameter with the one representing the shaft in the orthographic. The distance ab between the two centers is the length of the cylindrical shaft of the object.

(2) Using points b and c as centers, draw the arcs which represent the rounded top of the object.

(3) With point d as center, draw the circle with the same diameter as the one in the orthographic. As shown by the side view, this is a circular hole which extends through the object.

(4) Using d and e as centers and a radius the same as the orthographic, draw the two arcs which represent the rounded bottom part of the object.

(5) Draw tangent lines between both the top and bottom arcs and the arcs with centers a and b, thus completing the contour of the object.

(6) Heavy-in all final lines and erase construction lines, as shown in part C.

Circles in Oblique. It is not always possible to place an object so that all its curved surfaces are parallel with the image plane. In such cases, a four-center approximate ellipse may be used to represent circles which are not parallel with the image plane. However, this method can be used only when the sides of the inclosing parallelogram are equal. In a cabinet drawing or in any oblique drawing where the receding axis is foreshortened, the curve must be plotted by coordinate (offset) measurements. The principles used in drawing an ellipse by this method are shown in figure 4-69.

Since the ellipse shown on the receding surface in figure 4-69 represents a circle on the surface of the object, the receding surface is first drawn as an orthographic view. This view is then used to establish coordinate points which are used to establish similar points on the receding surface. The ellipse is then drawn through these established points. The following steps are used to construct the ellipse.

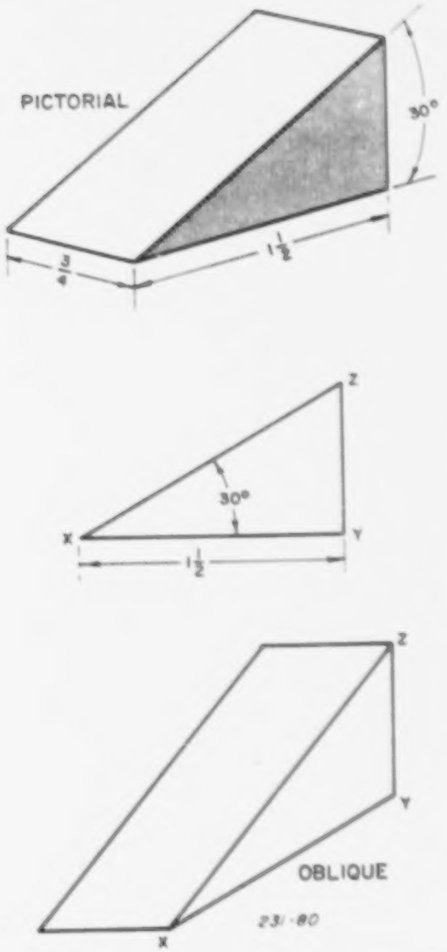


Figure 4-70. Angles in oblique projection.

(1) Draw an orthographic view of the receding surface on a separate piece of paper and position it on the front surface of the drawing as shown in the illustration.

(2) Divide the surface of the orthographic view and the receding surface of the drawing into the same number of equal vertical segments by drawing vertical coordinate lines as shown in the figure. As you know, the segments of the receding surface are one half the size of the orthographic segments.

(3) On the orthographic, draw horizontal coordinate lines through the points at which the vertical coordinate lines intersect the circle. Extend these lines to the right edge of the view.

(4) Draw receding lines from the right ends of the horizontal coordinate lines. The intersections of these receding lines and the vertical coordinate lines on the receding surface which correspond to the intersections of the vertical coordinate lines, horizontal coordinate lines, and the

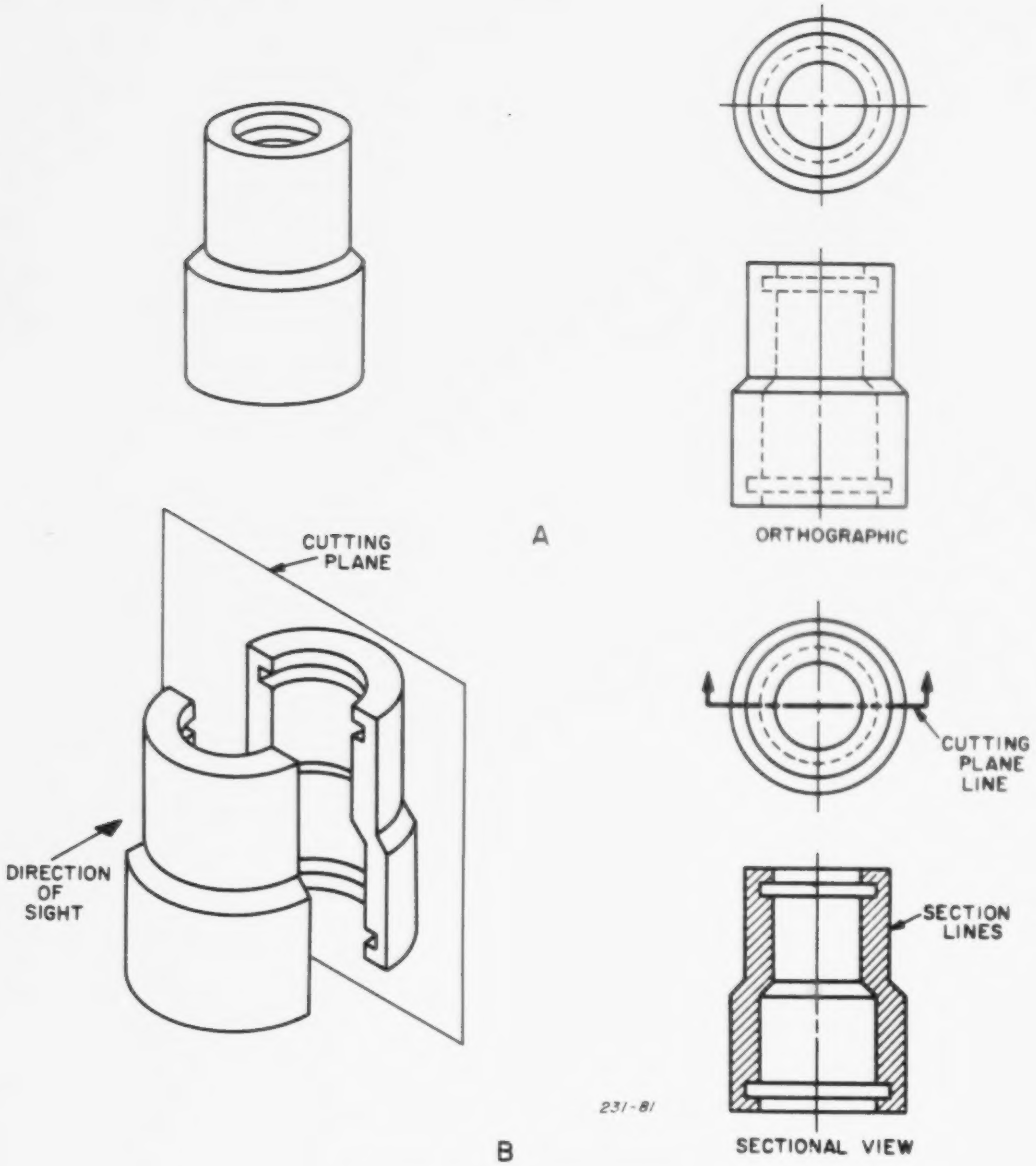


Figure 4-71. Principles of a sectional view.

circle in the orthographic view establish the path of the ellipse.

(5) Use an irregular curve to draw the finished ellipse.

(6) Remove the orthographic drawing and erase all construction lines.

Angles of Oblique. To draw an angle of a specified number of degrees on the receding plane of an oblique drawing, you must first convert the angle into linear measurements. For example, if you are given the dimensions and a sketch of the pictorial shown in figure 4-70, you must construct a right triangle whose dimensions are the same as the given angle. You can then use the dimensions of this triangle to obtain the correct dimensions of the angle on the receding surface. The following steps are used to construct the 30° angle of the receding surface of the object shown in figure 4-70.

(1) Construct the right triangle with the dimensions XY and the 30° angle. The purpose of this triangle is to establish the length YZ.

(2) Draw a line representing the receding axis of the oblique drawing.

(3) Mark off the given dimension XY on this receding line.

(4) Draw a vertical line from point Y on the receding line.

(5) From the triangle drawing, obtain the dimension ZY and mark this distance off along the vertical line, starting at point Y.

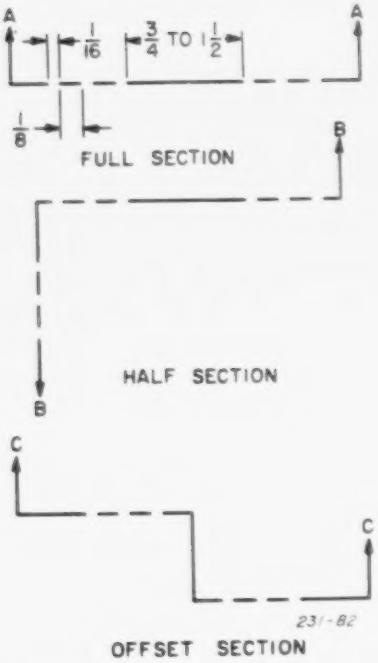


Figure 4-72. Cutting plane lines.

(6) Draw a line between point Z on the vertical line and point X on the receding line. This completes the required angle.

(7) Complete the oblique by drawing the two horizontal lines from points X and Z by marking off the depth dimension and by drawing the sloping line parallel to line XZ.

Exercises (049):

1. What determines whether a drawing is a cavalier or cabinet projection?
2. Why is an orthographic view of a circle drawn before the ellipse in a cabinet drawing?
3. To draw an angle of specific size on the receding plane, the angle must be converted into what measurement?

4-8. Sectional Views

Sectional views are used to clarify the internal details of an object which can be represented only by hidden lines in regular orthographic (exterior) views. When the internal details are complicated, a perplexing mass of hidden (invisible) lines may be required to describe the invisible features on an exterior view. Whenever an illustration becomes so confused by hidden lines that it is difficult to read, it is customary to draw one or more sectional views.

A sectional view is one obtained by imaging the object cut by a cutting plane and a portion moved so that the internal details can be seen clearly. Thus, the invisible lines of a regular view become visible lines in a sectional view. A view may be partial sectional or full sectional, depending upon the particular requirement.

050. Define the term cutting plane and specify its purpose.

Cutting Plane Lines. Since a sectional view is obtained by imagining the object to be cut by a plane passing through it in a selected position and direction, this plane is called the *cutting plane*. The purpose of the cutting plane is to cut off a portion of the object, thereby exposing the internal features in the remaining portion. The position and direction of the cutting plane are determined by you, the draftsman. You must visualize the object being cut by the plane placed in various positions, and then select the position which adequately exposes the desired internal details. The pictorial drawings in figure 4-71 show an object before and after being cut by a plane.

The orthographic top and front (exterior) views of the object are shown in part A of figure 4-71. Notice the hidden lines in the front view which are required to show the internal details. Part B shows the left portion of the object imagined to be removed by the cutting plane, thereby exposing the interior features in the right portion which lies behind the cutting plane. Observe that the hidden lines in the orthographic front view are shown as solid outlines in the sectional view. Notice how much clearer the internal features appear in the sectional view.

The arrow in the pictorial part of figure 4-71 shows the direction in which the remaining portion of the object is viewed. Section lines in the sectional view represent the surfaces cut by the cutting plane. In this figure, the sectional view is constructed by projecting from the top view in the same way as the front orthographic view.

A cutting plane line represents where a section of the object is imagined to be removed by the cutting plane. The cutting plane is indicated only in the view showing the plane as a line; therefore, a cutting plane line represents an edge of the cutting plane. The top edge of the cutting plane is shown by the cutting plane line in the top view of part B, figure 4-71.

Figure 4-72 shows three types of cutting plane lines whose parts are drawn to conventional proportions. The dimensions shown on line AA are approximate, and may be increased or decreased in accordance with the size of the drawing. All cutting plane lines are weighted heavily. Arrowheads at the ends of any type of cutting plane lines are used to indicate the direction in which the imaginary cut surface is viewed. Since the cutting plane line represents the edge of the plane, it is apparent that the cut surface is viewed through the surface of the cutting plane.

Line AA represents the edge of a cutting plane which cuts the object into two sections, either lengthwise or crosswise.

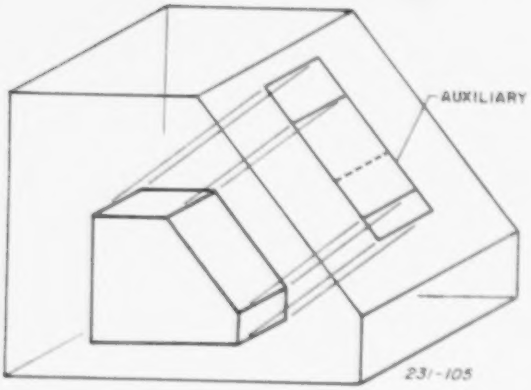

AUXILIARY
231-105

Figure 4-73. Auxiliary plane position.

When an object is cut in this manner, a full sectional view is obtained.

Line BB represents the edges of two right-angle cutting planes which cut a section in half. The view obtained is a half-section. In a half-section view, one-quarter of the object is imagined to be removed.

Line CC represents the edges of a cutting plane which is "bent." In drawing an irregular object, it is often desirable to show several features which do not lie in a straight line. This is done by "offsetting" or bending the cutting plane. The view obtained is an *offset section*, and the "bends" may be at any angle.

A cutting plane line may be omitted when the position of the cutting plane is obvious. This practice is acceptable in the case of symmetrical objects, where the cutting plane is understood to pass through the axis of symmetry. In brief, the cutting plane line may be omitted unless it is needed for clarity. However, if an offset cutting plane is used, its position must always be shown by cutting plane lines.

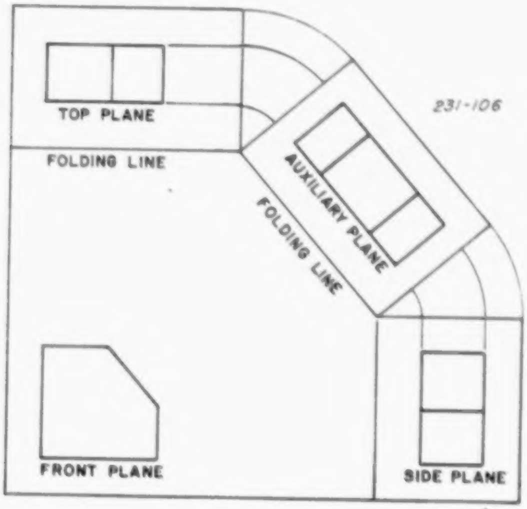

TOP PLANE
231-106
FOLDING LINE
AUXILIARY PLANE
FOLDING LINE
FRONT PLANE
SIDE PLANE

Figure 4-74. Complete auxiliary.

Exercises (050):

1. What is the purpose of a cutting plane?

2. What is indicated by arrows at the ends of cutting plane lines?

4-9. Auxiliary Views

On many objects, there are surfaces and lines which do not show in true size and shape because they are not parallel to any one of the regular projection planes. To build an object, the builder must know the true lengths of all lines, the true sizes and shapes of all planes, and, in some cases, the true size of the angle between intersecting planes. When these conditions are not shown in regular top, front, and side

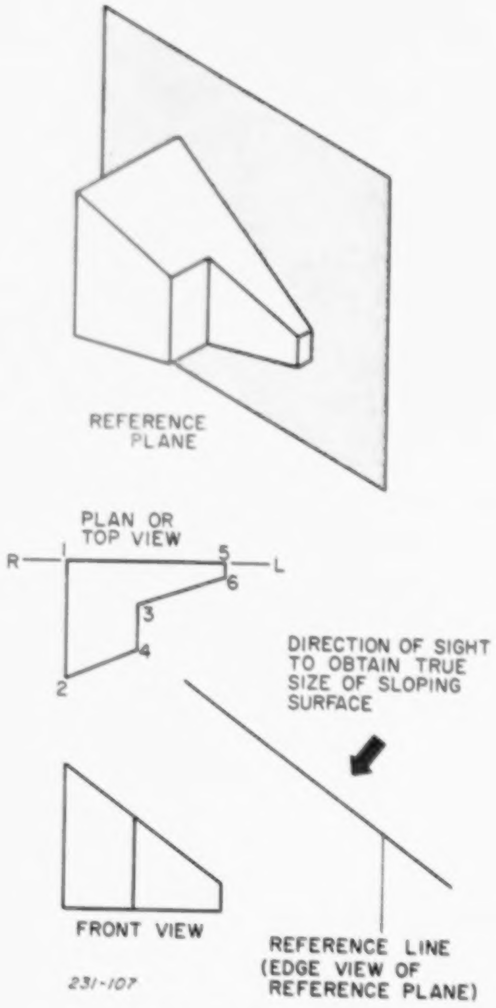

REFERENCE PLANE
PLAN OR TOP VIEW
R
1
5
L
6
3
4
2
DIRECTION OF SIGHT TO OBTAIN TRUE SIZE OF SLOPING SURFACE
FRONT VIEW
REFERENCE LINE (EDGE VIEW OF REFERENCE PLANE)
231-107

Figure 4-75. Object with inclined face in glass box.

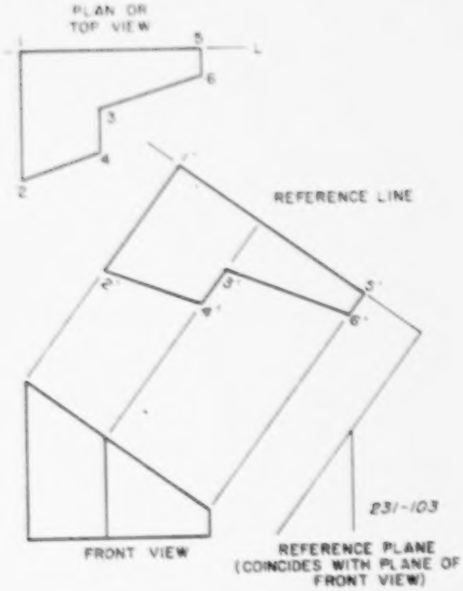


Figure 4-76. Open glass box showing auxiliary plane position.

views, additional planes of projection must be set up to show views giving the needed information. These additional planes are called auxiliary planes, and the views are called auxiliary views. In this section, we'll discuss the glass-box method for explanatory purposes and then cover the method more generally used—sometimes called the customary method of projection.

051. Name the two basic methods of projections, and tell how to obtain the true size and shape view.

Glass-Box Method. Figure 4-73 shows an object with an inclined face inclosed in a glass box. Notice that the auxiliary plane is parallel with the inclined face. Therefore, the projection of the inclined face on this plane is true size and shape. Using the same method of opening the glass box as shown in figure 4-74, the various planes are hinged around the front plane and are rotated until they coincide (lie in the same plane) with the front plane. The result of this rotation is shown in figure 4-74.

Although the glass-box method is rather cumbersome and seldom used, it shows the principles of auxiliary views. Now we'll discuss the customary method of projection.

Customary Projection Method. In this method, you assume a plane which either coincides with or is parallel with a selected surface of the object. In either case, that portion of the object projected upon this plane is shown on the drawing. This statement applies to all types of orthographic projection, including auxiliary projection.

Figure 4-75 shows the projected top view and front view of the object shown in the pictorial drawing. It is apparent that an auxiliary view is necessary to show the slanting surface in true size and shape. This auxiliary view is drawn as if we were viewing the surface in a direction perpendicular to the inclined face, as shown by the arrow.

To obtain the true size and shape view, imagine a plane placed so that it is parallel to the inclined face. Notice that the reference line represents the edge view of the reference (auxiliary) plane. Since the reference line is parallel with the inclined surface, the reference plane is parallel with the inclined surface. Consequently, the inclined surface projected on this plane is true size and shape.

Figure 4-76 shows the reference plane rotated to coincide with the plane of the front elevation. Notice that the plane is rotated about the reference line—the reference line (edge of plane) remains in the same position as it is in figure 4-75.

On the imaginary auxiliary plane, reference lines can be placed at any logical distance from the inclined surface of the object. If the object is nonsymmetrical, such as the one shown thus far, the reference line represents the edge of the auxiliary plane. This line is called a nonsymmetrical reference line. However, if the face of the object is such that the auxiliary view will be symmetrical, the reference line is the line of symmetry. In this case, the line is called a symmetrical reference line, and it lies between and is parallel with edges of the auxiliary plane.

Exercises (051):

1. What are the two basic methods of projection?

2. How would you obtain the true size and shape view?

052. Specify how an auxiliary view is used.

Classification of Auxiliary Views. Auxiliary views fall into three general categories: a single or primary auxiliary view, a partial auxiliary view, and a complete auxiliary view. Let's discuss them in this order.

Single or primary auxiliary views. These views may be subdivided into front auxiliary view, plan or top auxiliary view, and side or end auxiliary view. A single or primary auxilliary view is obtained by projecting from a principal view of the object, in which the inclined surface of the view appears as a line or edge. Figure 4-76 shows the auxiliary view projected from the front view. Since the projection is from the front view, it is a front auxiliary view. The principles of projecting auxiliary views from the plan or top view and the side or end view are the same as from the front view.

Partial auxiliary views. Since figure 4-76 shows only the inclined face of the object, it represents a partial auxiliary view. Since partial auxiliary views are the most commonly used, in the next section we'll present the principles of drawing them.

Complete auxiliary views. Occasionally, it may be necessary to indicate how the entire object appears when the

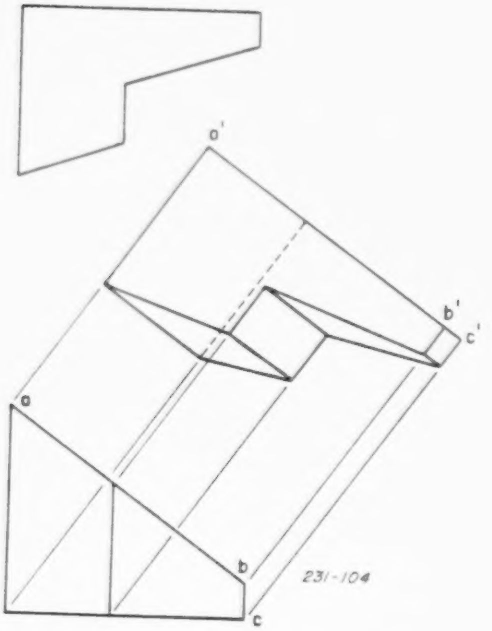


Figure 4-77. Object requiring auxiliary view.

inclined face is shown in true size and shape. A complete auxiliary view is shown in figure 4-77. Notice that sloping edge ab projects true length as shown by a'b', but edge bc is foreshortened as shown by b'c'. This is because the plane in which bc lies is not parallel with the auxiliary plane. Compare other dimensions in the same manner.

Now let's cover the basic methods of drawing nonsymmetrical and symmetrical partial views.

Partial Auxiliary View Drawing of Nonsymmetrical Object. In making a partial auxiliary view of a nonsymmetrical object, the first step is to draw a reference line that is parallel to the line which is the edge of the inclined surface (see fig. 4-75). Since this reference line is the edge of the auxiliary plane, this plane is imagined as being parallel with the inclined surface. Hence, any line which lies on the auxiliary plane will also be parallel with the inclined surface.

Next, draw light projection lines at right angles from all points on the inclined surface (see fig. 4-76) to the reference line. Then lay off along these projection lines the perpendicular distances from the near edge of the surface as shown in the plan view. In this case, there are three lines, lines 1-2, 3-4, and 5-6, in the plan view, which show as 1'-2', 3'-4', and 5'-6' in the auxiliary view. Notice that lines 1-2, 3-4, and 5-6 are equal in length to lines 1'-2', 3'-4', and 5'-6', respectively. As you can see, the length of the reference line is the same as the inclined surface of the front view. Furthermore, notice that lines 2'-4' and 3'-6' are not the same length as the corresponding lines in either the plan view or the front view because now they are shown in true length.

Remember that the auxiliary plane is imagined to be hinged to the plane to which it is perpendicular and is revolved into the plane of the paper, as shown in figure 4-74.

Drawing a Partial Symmetrical Auxiliary View. Often it may be advantageous to position the reference plane through the center of the object. If the object is symmetrical, the construction is not difficult if the reference line is used as a center-line axis. Figure 4-78 shows a symmetrical curve plotted on a reference line which is a center-line axis. The partial auxiliary view is constructed by locating a series of spaced points along the curve by projecting lines determined by points established on the top view. Notice that the top or plan view shows the diameter of the circular cylinder, and the front view shows the slope and length of the inclined portion of the cylinder.

In constructing the auxiliary view of the inclined surface, draw reference (center) line R'L' parallel to the inclined surface and at any convenient distance from the surface; and draw reference line RL in top view through the center of the circle, as shown in figure 4-78. Next, draw some vertical lines which are perpendicular to the reference or center-line RL (top view) to intersect the inclined face, and extend them upward to intersect the upper portion of the circle circumference. For example, line 1-2 in the top view intersects inclined edge XY at point B. The other points on line XY are established in the same manner. Then from point B, draw line BC parallel with lines XR' and YL'. (Lines XR' and YL' are perpendicular to the inclined edge XY.) Continue this procedure by drawing the parallel lines from the other points located on the inclined edge, as shown in figure 4-78.

Now, notice that points 1 and 2 in the top view are equidistant from the center line; consequently, the length H1 is equal to the length H2. Since this is also true of points 3 and 4, 5 and 6, etc., we can locate points on the curve in the auxiliary view. On line BC, mark off H'1' equal to H1 and H'2' equal to H2, so that points 1' and 2' are equidistant from reference line R'L'. These two points 1' and 2' are points on the ellipse of the auxiliary view. Repeat this operation until sufficient points are established for drawing the ellipse through them, using an irregular curve.

You can see that, if more points are located on the inclined line, more points can be established on the ellipse and, consequently, a smoother curve may be drawn.

Exercises (052):

1. When is an auxiliary view required?

2. Is an auxiliary plane of glass box rotated in the same manner as the other planes?

3. If an auxiliary view is symmetrical, the reference line is on the ________ of ________.

4-10. Dimensioning

In addition to the complete shape description of an object, a drawing must give the complete size and location description; that is, it must be dimensioned. A properly dimensioned drawing must show extension lines and dimension lines terminated by arrowheads, easily read numerals indicating size, finish marks, and notes with or without leaders. From a drawing with these dimension standards, a machinist can make parts that fit properly when assembled. Dimensions are given as linear distances, angles, or notes. Learning to dimension consists of three major factors:

(1) You must learn the techniques of dimensioning, and know such things as the character of the lines used, the spacing of dimensions, and the making of arrowheads.

(2) You must learn the rules of dimension placement on a drawing to assure logical and practical arrangement with maximum legibility.

(3) You also must learn how to choose. These choices are based on the function of the part and the manufacturing process.

053. Specify how to provide dimensioning for a drawing.

The two basic methods used to give a distance on a drawing are a dimension and a note. A dimension is used to give a distance between two points, lines, planes, or combinations of points, lines, or planes.

Typical dimensions are shown in foldout 2. Refer to this illustration as you read the following description of the dimension elements.

NOTES. This method of distance description (see the local note, item 1, at the top of foldout 2, and the general note, item 2, at the left center of the foldout) provides a means of giving explanatory information along with a size dimension. The leader and arrowhead of a local note refer to the word statement of the note to the proper feature of the drawing. Notes applying to the object as a whole (general

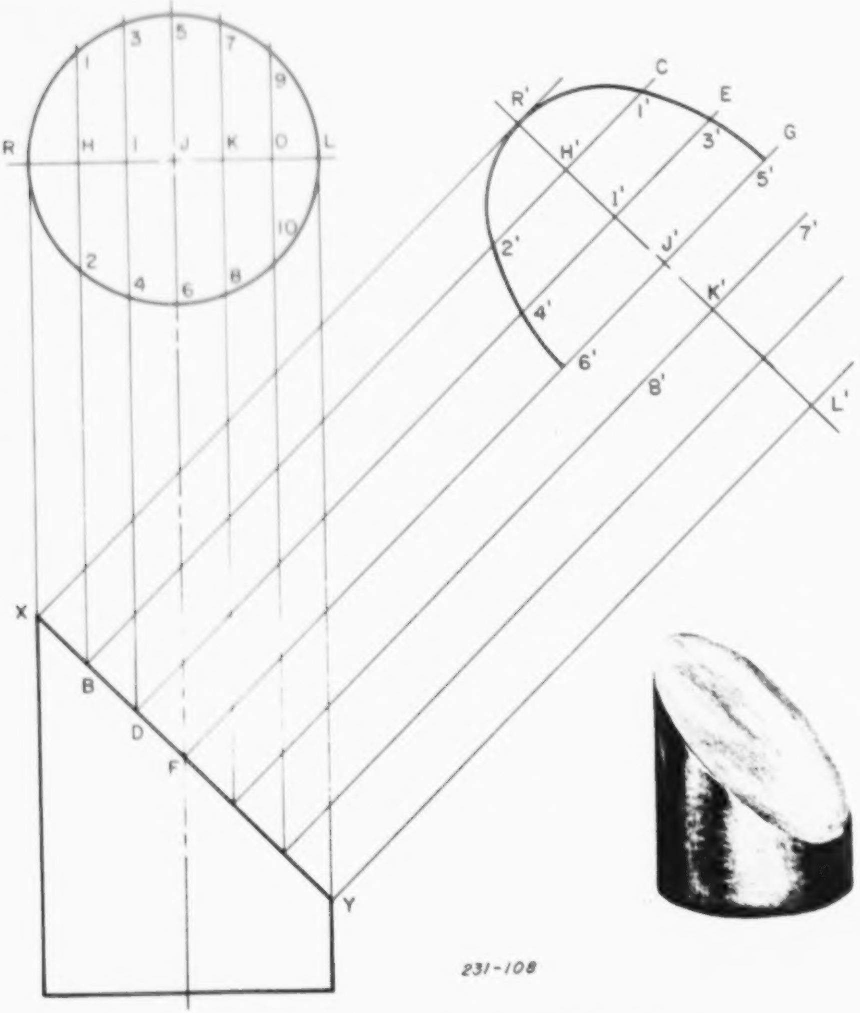


Figure 4-78. Symmetrical auxiliary view.

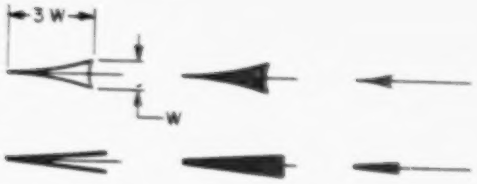


Figure 4-79. Arrowheads.

note) are given without leaders. These general notes are placed in some convenient place on the drawing.

Lines Used in Dimensioning. Extension lines, dimension lines, and leaders are thin solid lines placed on the drawing for dimensioning purposes. They are made the same thickness as center lines so that they contrast with the heavier outlines of the object. Refer to foldout 2 as you read the following characteristics of each line.

Extension line. An extension line (item 3) extends from the view to the dimension outside the view. Extension lines start about one-sixteenth of an inch from the outline of the object and extend about one-eighth of an inch beyond the last dimension line. As shown in the upper-left portion of foldout 2, outlines and extended center lines may be used as extension lines.

Dimension line. A dimension line (item 4) is a thin, solid line terminated at each end by arrowheads. It indicates the direction and extent of the dimension. A numerical value placed along the dimension line specifies the number of units indicated. When the numerals are in a single line, the dimension line is usually broken near the center, and the numerals are placed in the open space. When the numerals are in two lines, the dimension line is not broken, and one line of numerals is placed above the dimension line and the other below.

Leader. A leader (item 5) is a thin, straight line that begins at a dimension or note and terminates in an arrowhead at the point on the drawing to which the dimension or note refers. The note end of a leader usually terminates with a short horizontal bar at the mid-height of the lettering at either the beginning or ending of the note. Leaders that end at circles or arcs are drawn as radial lines; that is, if extended, they would pass through the center.

Arrowheads. The pointing ends of leaders and both ends of dimension lines are terminated with arrowheads (item 6). Draw these pointing symbols freehand. Use either one stroke or two strokes to form the point. Then complete the shape by drawing a line across the open end. If you use the one-stroke method to form the point, make the stroke toward the point and then away from it. If you use two strokes, make both strokes toward the point. After completing the shape of the arrowhead, fill in the center.

Figure 4-79 shows the two common shapes of arrowheads. One has curved sides; the other has straight sides. Notice the proportion of the length to the width. The length of the arrowhead with curved sides is three times the width. Straight-sided arrowheads are longer and narrower and are made with a broader stroke, which produces a blunter point. The two small arrowheads on the right indicate the normal size used on small drawings. These are approximately one-eighth of an inch long. For large drawings, arrowheads may be as long as three-sixteenths of an inch.

Dimensions. Since the numerical value or dimension (item 7, FO 2) is the most important element of dimensioning, the numerals must be carefully lettered. Either a vertical or an inclined style can be used. One-eighth of an inch for small drawings and five thirty-seconds of an inch for larger drawings are good general sizes.

Common fractions. As shown in figure 4-80, a dimension may consist of whole numbers, fractions, feet and inches, or decimals. When common fractions are used, the fraction bar is placed parallel with the guide lines, and the numerator and denominator are made somewhat smaller than the whole number so that the total height of the fraction is twice that of the whole number. The numerals do not touch the fraction bar. Notice that, when the dimension occupies the open space of a dimension line, the fraction bar is aligned with the dimension line, but the two do not touch. The three presentations at the right of the top row show the different ways to place the dimension when the space is limited. In one method you place the dimension figure between the extension lines and the dimension lines on the outside pointing toward the figure. When the space is too small to allow enough room for a figure, the dimension may be placed as in the two presentations on the right.

Feet and inches. Dimensions in feet and inches are represented with the symbols (') and ("), as shown in the center row of figure 4-80. When the dimension is in even feet, such as 6 feet and no inches, the dimension is written as 6' 0". When a dimension is in feet and a fraction of an inch, a zero is used in front of the fraction; for example, 6' 0½". When the dimension is all in inches, the inch mark is usually omitted from all dimensions and notes unless there is some possibility of misunderstanding. For example, a note consisting of 1 DRILL would be written as 1" DRILL so that it would not be interpreted as "drill one hole."

On Air Force machine drawings, if no foot or inch marks appear, the dimension values indicate inches, unless a different unit of measurement is indicated by a general note. Parts of inches are given as common fractions or decimal fractions. Three different systems are used.

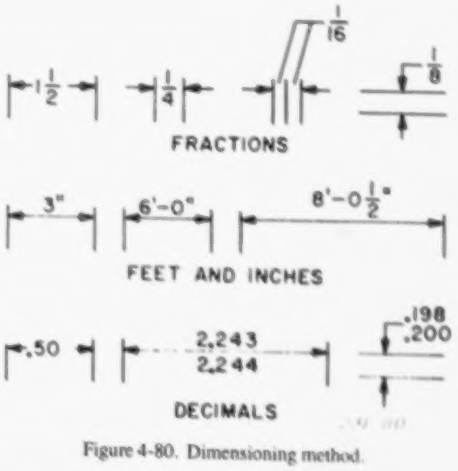


Figure 4-80. Dimensioning method.

Systems of writing dimension values. When the smallest fraction of a dimension is one-sixty-fourth or an inch or greater, the *common-fraction system* is generally used. With this system all dimension values are written as units and common fractions. The common fractions used are 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, and the appropriate multiples of these fractions. Values containing these fractions can be laid out with a steel tape or with a scale graduated in sixty-fourths of an inch.

The *common-fraction, decimal-fraction system* is used principally in machine drawing whenever the degree of precision required calls for fractions of an inch which are smaller than those on the ordinary steel scale. The method used is as follows: (1) Give values in units and common fractions for distances not requiring an accuracy closer than one sixty-fourth inch, and (2) give values in units and decimal fractions for distances requiring greater precision. The decimal fractions are given to as many decimal places as needed for the degree of precision required. In any case, the decimal point is made somewhat larger than is normal so that its position will not likely be misinterpreted.

The *complete decimal system* uses two-place decimal fractions exclusively for all dimension values. The digits after the decimal point are preferably written to even fiftieths, such as .02, .04, .06, etc., so that when halved, as for radii, etc., the resulting figures are two-place decimals. Writing the values in even fiftieths allows the use of scales divided in fiftieths, which are much easier to read than scales divided in hundredths.

Dimension values for distances requiring greater precision than that expressed by the two-place decimal are written to three, four, or more decimal places as needed for precision.

When decimal equivalents are used for common fractions, some of them come out to a greater number of decimal places (significant digits) than is necessary or desirable for use as a dimension value. In such cases, the decimal should be adjusted or rounded off to a smaller number of decimal places. The following procedure is recommended:

a. When the figure beyond the last figure to be retained is less than 5, the last figure retained should not be changed. For example, 3.14162 when rounded off to four places becomes 3.1416.

b. When the figure beyond the last figure to be retained is more than 5, the last figure retained is increased by 1. For example, 1.6875 becomes 1.69 when rounded to two places.

c. When the figure beyond the last place to be retained is exactly 5 with only zeros following, the preceding number, if even, is left unchanged; if odd, it is increased by 1. For example, 1.8125 becomes 1.812 and 1.6875 becomes 1.688 when rounded off to three places.

Exercises (053):

1. By what two methods may a distance be given in a drawing?

2. List and identify the lines used in dimensioning.

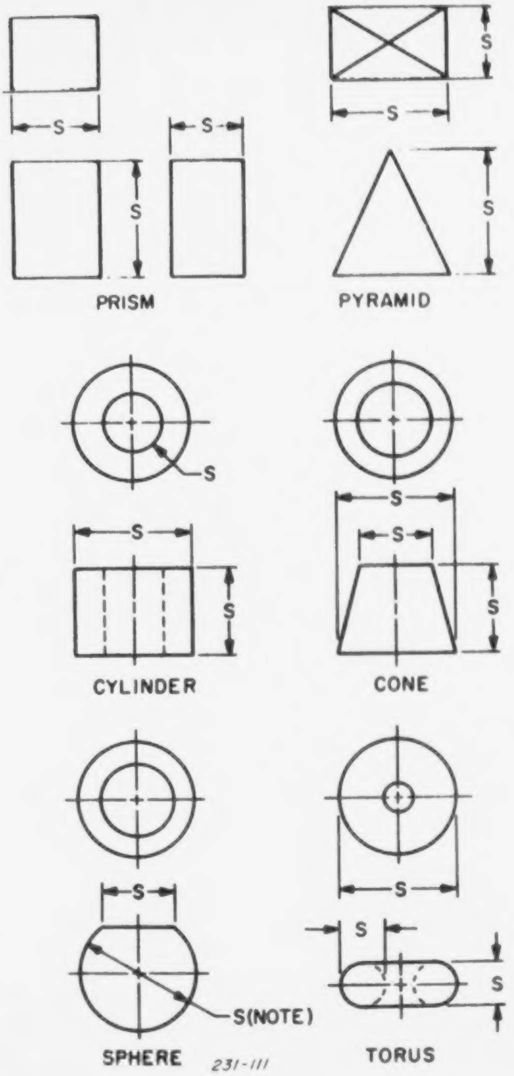


Figure 4-81. Dimensioning geometric shapes.

3. What is the length of an arrowhead?

4. Why place a finish mark on a drawing?

054. Specify how to provide size, location, and standard dimensioning.

Any object can be broken down into a combination of basic geometric shapes or forms. These forms are usually prisms, cylinders, pyramids, and cones. Any form may be positive or negative, in the sense that a steel shaft is a positive cylinder and a round hole is a negative cylinder. This feature of breaking down an object into simple geometric forms is the basis of dimensioning.

The complete description of an object consists of giving the shape, size, and location of all the object's basic forms. These dimensions must show the size of each geometric form and the relative location of all forms. Knowing how to dimension simple geometric forms is essential to describing any object.

Size Dimensioning. Since every solid has three dimensions, each of the geometric forms which make up the object must have its height, width, and depth indicated in the dimensioning. These distance values are called size dimensions. Refer to figure 4-81 as you read the following information on dimensioning simple geometric forms.

Prism. The prism is the most common shape found in objects. Square, rectangle, or triangular prisms require three dimensions. The method of dimensioning a rectangular prism is shown in the illustration. The letter "S" in the illustration indicates that this is a size dimension. Notice that the dimensions are placed between the views. Since two views (the top and front views) are all that are necessary to adequately describe this particular prism, the depth dimension can refer to the top view and be in line with the height dimension, thus eliminating the need for the side view. For regular hexagonal or octagonal types of prisms, usually only two dimensions are given: the length and either the distance across the corners or the distance across the flats.

Pyramid. Right pyramids are dimensioned by giving the dimensions of the base and the altitude. Right pyramids are often frustums (portion of a pyramid with the pointed section removed) which require dimension of both bases.

Cylinder. A cylinder is the next most common geometric form. It obviously requires only two dimensions: length and diameter. The general method of dimensioning a cylinder is to give both its diameter and its length in the rectangular view. If clearness is gained, a diagonal diameter may be used in the view that shows the cylinder as a circle. The use of several diagonal diameters is usually confusing and should seldom be used. The radius of a cylinder is never given, since measuring tools, such as the micrometer caliper, are designed to check diameters. Small cylindrical holes, such as drilled, reamed, or bored holes, are usually dimensioned by means of notes specifying the diameter and the depth, along with the required shop operation.

The top view of the cylinder shown in figure 4-81 would be unnecessary if the dimension of the hole were placed on the rectangular view in the same position as the corresponding dimension on the view of the cone below. However, the dimension in this position would not indicate a diameter. In such cases where it is not clear from the view that a dimension indicates a diameter, the abbreviation "DIA" or "D" is given after the dimension figure.

Cone. Right cones are dimensioned by giving the altitude and the diameter of the base. They usually occur as frustums which require dimensions of height and both diameters. Oblique cones are dimensioned in the same way as right cones but with an additional dimension parallel to the base to give the offset of the vertex.

Sphere. A sphere is dimensioned by giving the diameter and adding the word "SPHERE." Figure 4-81 also shows how a flat surface on a sphere is dimensioned.

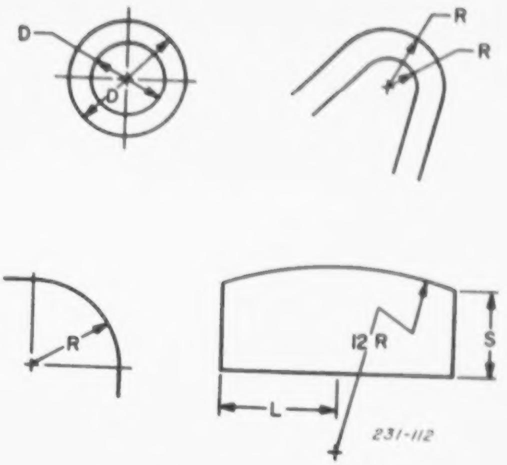


Figure 4-82. Dimensioning circles and arcs.

Torus. This doughnut-shaped form is dimensioned by giving its outside diameter and its thickness. As you can see in the figure, both of these dimensions are given on the front view.

Location Dimensioning. In addition to dimensioning the basic geometric shapes for size, you must give dimensions which will position each form in relation to the other. Establish the location or position in height, width, and depth directions. Locate rectangular shapes with reference to their faces and cylindrical and conic shapes with reference to their center lines and their bases.

Particular care must be exercised in the selection and placing of location dimensions, because upon them depend the accuracy of the operations in making a piece and the proper mating of a piece with other parts. To select location dimensions intelligently, you must first determine the contact surfaces, finished surfaces, and center lines of the basic geometric forms and, with the accuracy demanded and the method of production in mind, decide from what other surface or center line each should be located. Mating location dimensions must be given from the same center line or finished surface on both parts. Location dimensions may be from center to center, surface to center, or surface to surface.

Dimensioning Standard Features. Many basic shapes occur so often in mechanical parts that they can be considered as standard features. As such, they deserve special dimensioning consideration. The standard features include circles and arcs, curves, angles, chamfers, tapers, holes, countersinks, counterbores, spotfaces, and shapes with rounded ends.

Circles and arcs. The methods of dimensioning circles and arcs are shown in figure 4-82. For a circle the diameter is the essential dimension. When a series of concentric circles are dimensioned on their circular view, the dimension values should always read from the same direction, if possible.

Arcs are dimensioned by giving the radius on the view that shows the true shape of the curve. The dimension line for the radius is always drawn as a radial line and at an angle with the horizontal. A radial dimension line should never be drawn horizontally or vertically. A small cross is used to mark the center. The numerical value is usually followed by the letter "R," designating radius. If the size of the radius and the space for the value permit, both the dimension line and the value are placed inside the arc. If the space for the value is limited, the line may be placed inside and the value outside. For very small arcs, both the line and value may be placed outside the arc.

When the center of an arc lies outside the limits of the drawing, move the center closer along the center line of the arc, and jog the dimension line to meet the new center. Draw the portion of the dimension line adjacent to the arc as a radial line of the true center.

Curves. Dimension a compound curve composed of circular arcs by giving the radii of these arcs and the location of their centers, as shown in figure 4-83. An important

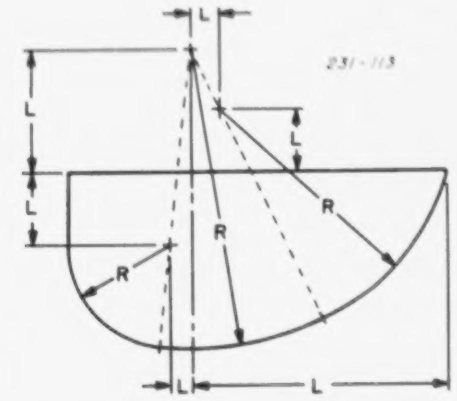

L
231-113
L
L
L
R
R
R
L
L

Figure 4-83. Dimensioning compound circular curves.

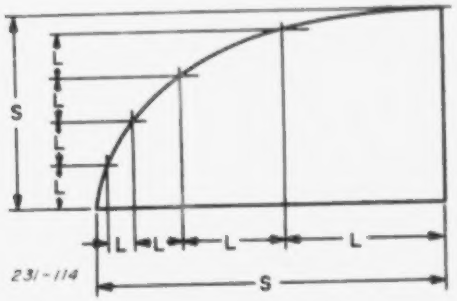

S
L
L
L
L
L
L
L
L
L
L
231-114
S

Figure 4-84. Dimensioning irregular curves.

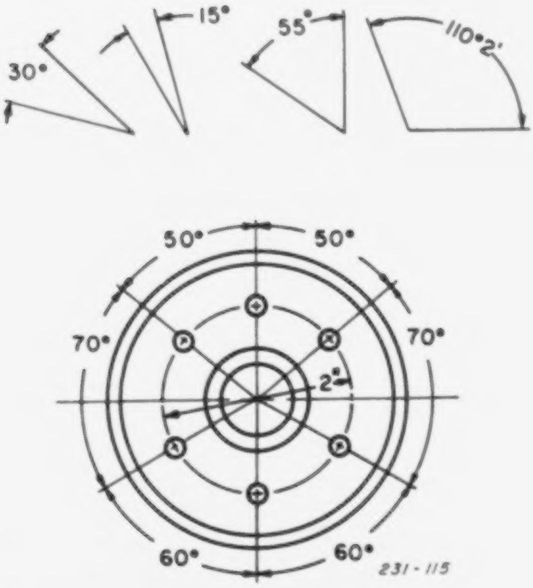

30°
15°
55°
110°2'
50°
50°
70°
70°
2°
60°
60°
231-115

Figure 4-85. Dimensioning angles.

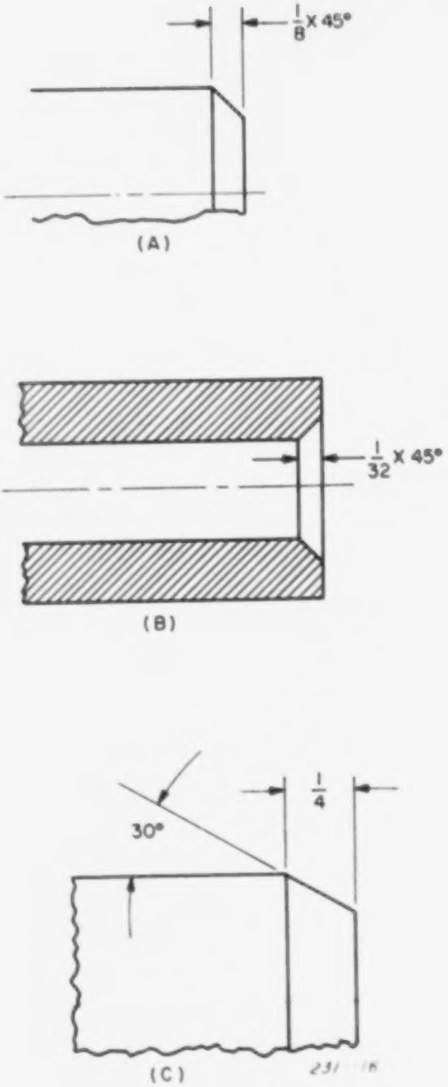

$\frac{1}{8}$ X 45°
(A)
$\frac{1}{32}$ X 45°
(B)
30°
$\frac{1}{4}$
(C)
231

Figure 4-86. Dimensioning chamfers.

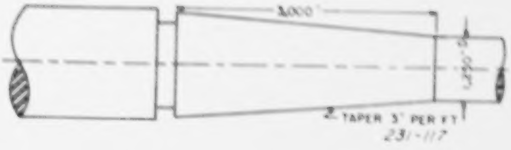


Figure 4-87. Dimensioning tapers.

consideration of this type of curve is the termination of each arc. For this particular curve, the arcs adjacent to each other terminate at the intersection of the curve and a line drawn through their centers.

Dimension curves are those for which great accuracy is not required by offset or coordinate points on the curves, as shown in figure 4-84. For greater accuracy, dimension from datum features. If the curve in figure 4-84 were dimensioned by the datum system, each horizontal dimension would be measured from the right vertical edge, and the vertical dimensions would be measured from the bottom edge. Thus, each dimension would be independent of the others and would be more accurate.

Angles. The dimension line for an angle is a circular arc with its center at the intersection of the sides of the angle. Four different methods of dimensioning angles are shown at the top of figure 4-85. The dimension value is usually placed horizontally, as shown in the three examples on the left. Occasionally, the value is aligned with the dimension arc, as shown on the right. As you can see, this system requires a large angle. A typical application of angle dimensioning is shown at the bottom of the figure.

The space available determines the position of the dimension value and dimension arc. When there is enough space, both value and arc are placed inside the two sides. When the space is limited, the value may be placed inside and the arcs outside, or both may be placed outside.

Chamfers. These are beveled external or internal edges. The 45° chamfers are dimensioned as shown in figure 4-8 at (A) and (B) or by a note, such as chamfer 1/8 × 45°. If the chamfer angle is other than 45°, it is dimensioned as at (C) of figure 4-86.

Tapers. A taper is a conical surface of a shaft or a hole. The method of dimensioning tapers depends on the method of manufacture and the accuracy required. If the specification calls for a standard taper, the dimension indicates one diameter and the length. The general method shows the diameters of both ends and the taper per foot. An alternate method is shown in figure 4-87. This method gives one diameter, the length, and the taper per foot. The taper per foot is defined as the difference in diameter in inches for one foot of length.

Holes. Drilled, reamed, bored, punched, or cored holes are usually dimensioned by note, giving the diameter, operation, and depth if required. The order of items in a note corresponds to the order of procedure in the shop in producing the hole. A typical note is as follows:

½ DRILL ⅝ DP - 2 HOLES

Two or more holes of the same diameter are dimensioned by a single note with the leader pointing to one of the holes. The leader generally points to the circular view of the hole. It is placed on the rectangular view only when it promotes clearness.

Figure 4-88 shows three methods of dimensioning the depth of a hole. Shown at A is the method used when the depth of the hole is not important to the functioning of the part. When the clearance at the bottom of the hole is important, use the dimension method shown at B. When the depth of the hole is important to the functioning of the part, dimension the hole as shown at C.

Measure the location dimensions for holes from a finished surface used as a datum plane, or from an important center or center line. Dimension holes equally spaced about a common center by giving the diameter (diagonally) of the circle of centers (commonly called the bolt circle) and by specifying "EQUALLY SPACED" on the note.

Locate holes which are unequally spaced about a common

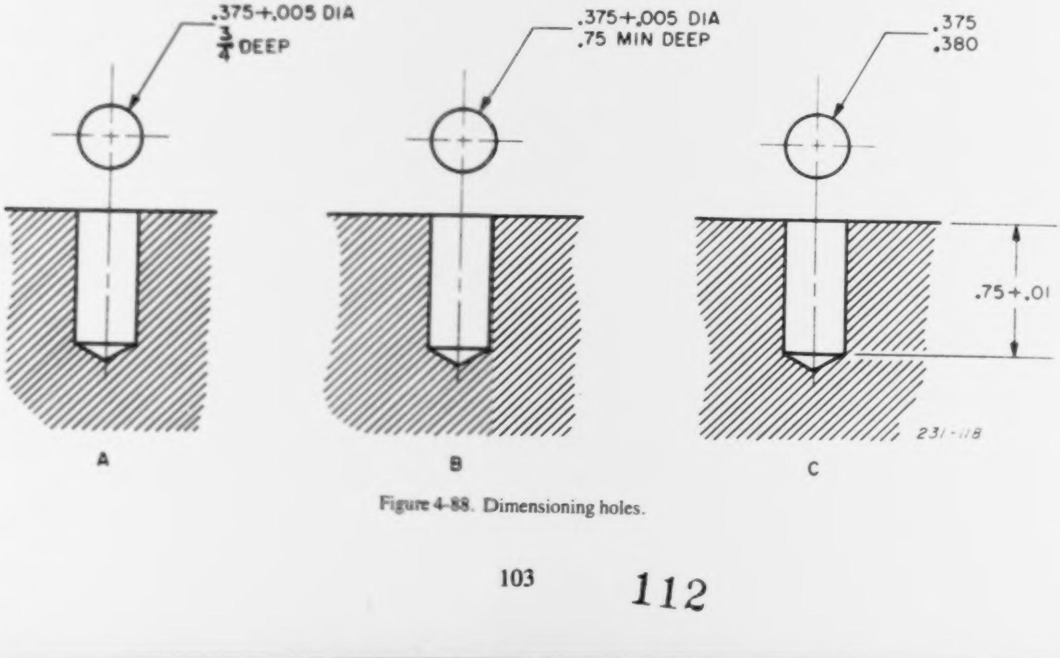
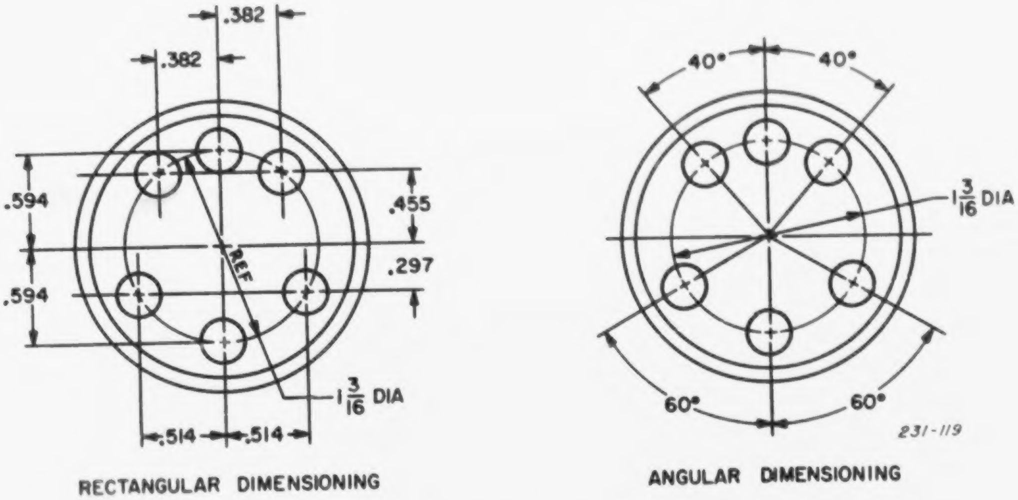


Figure 4-88. Dimensioning holes.



RECTANGULAR DIMENSIONING

ANGULAR DIMENSIONING

Figure 4-89. Two methods of dimensioning holes.

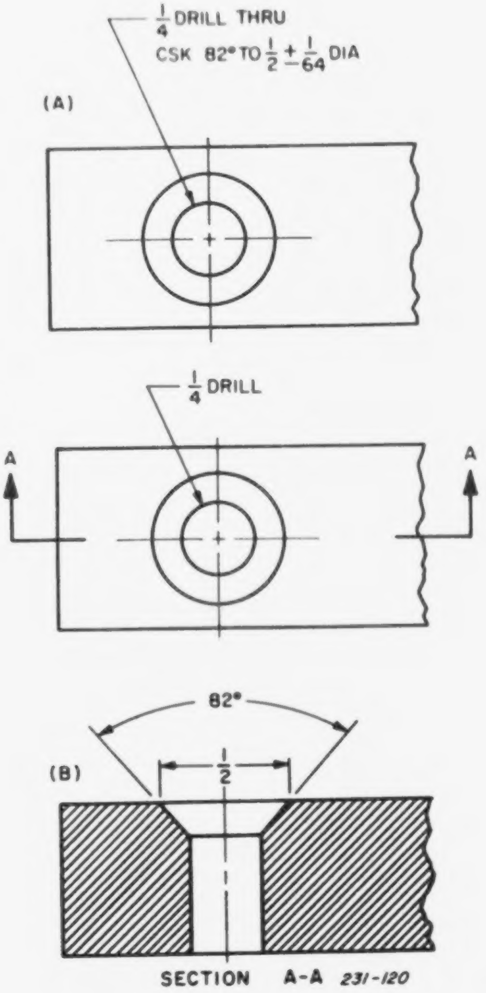


Figure 4-90. Dimensioning countersinks.

center by means of the two methods shown in figure 4-89. Locate them by means of the bolt circle diameter plus angular measurements with reference to only one of the center lines, as shown by the illustration on the right. Where greater accuracy is required, give rectangular or coordinate dimensions. This method is shown on the left. When using rectangular dimension, mark the diameter of the bolt circle "REF" to indicate that it is to be used as a reference dimension. Reference dimensions are given for information only. They are not intended to be measured and do not govern the shop operation.

The two small holes in foldout 2 are on a common center line. In such cases, one dimension locates one hole from the center line of the part; the other gives the distance between the holes. Note the omission of a dimension between the center line and the lower hole. This method is used when (as is usually the case) the distance between the holes is the important consideration. When the relation between the center line and each of the small holes is more important, the dimension is included between the center line and both holes, and the overall dimension is marked "REF."

Holes may be located by giving dimensions from a base line or datum. When all holes are located from a common datum, the sequence of measuring and machining operations is controlled, overall tolerance accumulations are avoided, and proper functioning of the finished part is assured. The datum surfaces selected must by more accurate than that required of any measurement made from them, must be accessible during manufacture, and must be arranged so as to facilitiate tool and fixture design. It may be necessary to specify accuracy of the datum surfaces in such terms as "straightness," "roundness," and "flatness."

Countersink. A countersink is a conical depression at the top of a hole to accommodate the head of a screw. Countersinks are dimensioned as shown in figure 4-90. The linear dimension indicates the distance across the top of the countersink. The dimensions of the rivet, bolt, screw, or other device to be inserted in the countersink determine the angle of its conical sides.

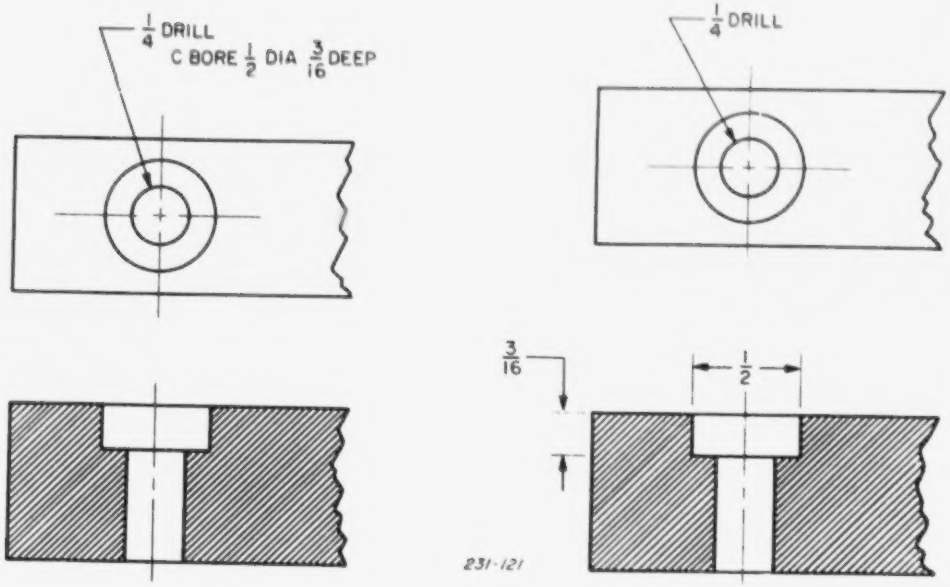

1/4 DRILL
C BORE 1/2 DIA 3/16 DEEP
1/4 DRILL
3/16
1/2
231-121

Figure 4-91. Dimensioning counterbores.

***Counterbore*.** The counterbore is an enlargement of the end of a drilled hole. It is cylindrical in shape and deep enough to allow a specific clearance. Each counterbore is dimensioned by a note with the abbreviation "C BORE," a leader, the diameter, and the depth of the bore. The two methods of dimensioning a counterbore are shown in figure 4-91.

***Spotface*.** A spotface is a machined area around a hole to permit accurate seating of a bolthead, washer, or nut. A spotface is specified by a leader from a note carrying the abbreviation "SF" and giving the diameter of the spotface. This leader-note combination is usually grouped with the leader and note giving the diameter of the hole, as shown in figure 4-92.

***Shapes with rounded ends*.** Methods of dimensioning shapes with rounded ends depend upon the degree of

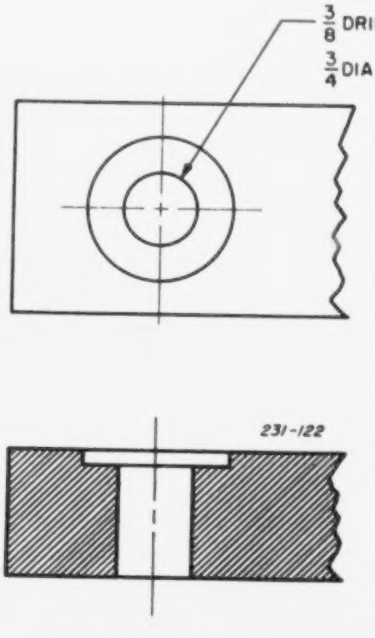

3/8 DRILL
3/4 DIA SF
231-122

Figure 4-92. Dimensioning spotfaces.

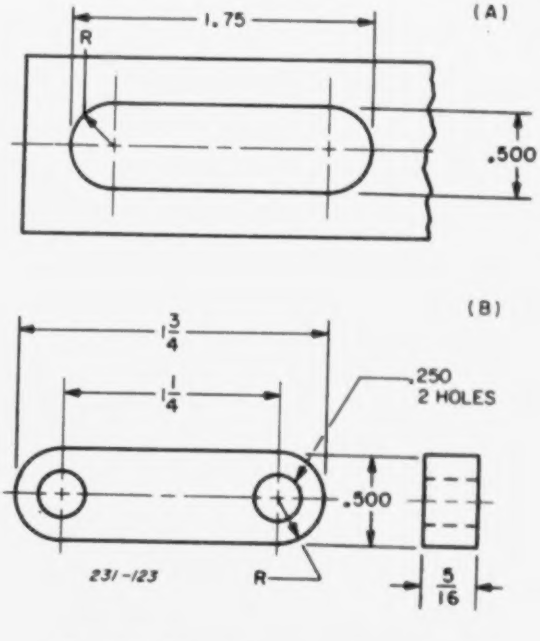

1.75
(A)
R
.500
(B)
1 3/4
1 1/4
.250
2 HOLES
.500
231-123
R
5/16

Figure 4-93. Dimensioning parts with rounded ends.

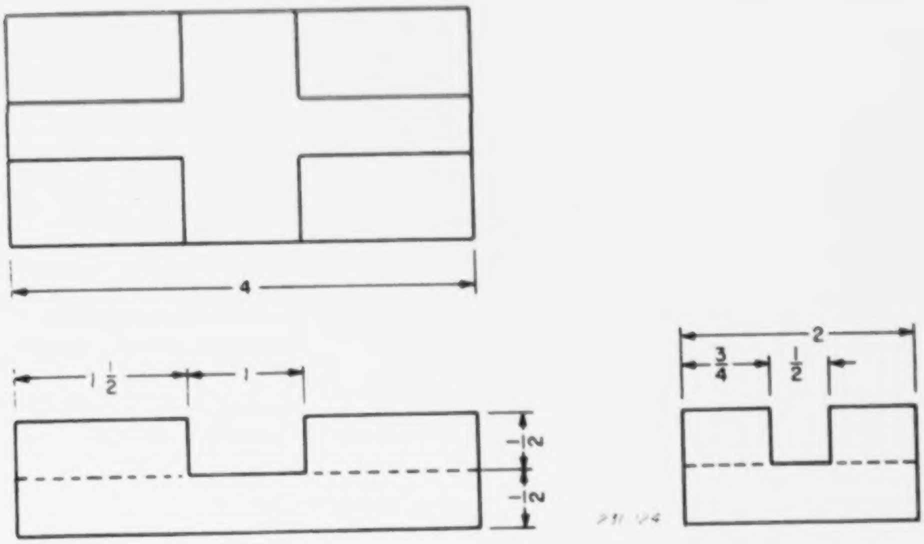


Figure 4-94. Dimensioning placement.

accuracy required. When extreme accuracy is required, the methods shown in figure 4-93 are recommended. The top illustration shows the dimensioning required for a rounded-end slot, and the bottom illustration shows the dimensioning required for a rounded-end link. Overall lengths of rounded-end shapes are given in each example. The width of the slot and the link are given and the radii are indicated, but without specific values. In dimensioning the link, the center-to-center distance is required because it is necessary to locate the holes accurately.

When precision is not necessary, the two parts may be dimensioned by giving the distance between the centers, the width, and the radius of the rounded end of each shape. Of course, the diameter of the holes in the link must also be given.

Exercises (054):

1. What is meant by size dimensioning?

2. What is the most common shape found in objects?

3. Identify a right cone, a frustum of cone, and an oblique cone.

4. What is meant by location dimensioning?

5. List the shapes that are considered standard features.

055. Specify the placement and order of dimensioning elements.

With clarity the important consideration, there are many dimensioning practices or principles, some with the force of a rule, that must be used in dimensioning drawing. Most of these practices are concerned with the placement of dimension elements and the procedure for dimensioning.

Placement of Dimensions. In addition to the methods of dimensioning basic geometric forms and shapes that we have already discussed, the following principles or rules apply to good dimensioning.

a. Place dimensions between views whenever possible (see fig. 4-94). If this is not possible, the next best position is on the outside of the views. When it is impossible to use either of these two positions, place the dimensions on the views themselves. If you place the dimension on the surface of a sectional view, omit the section lining around the numbers.

b. Dimensions must read from the bottom and right side of the sheet of paper unless the unidirectional system of dimensioning is used. This means that the dimensions are placed in the position shown in figure 4-94. As you can see, the horizontal dimensions run from left to right, and the vertical dimensions run upward. In the unidirectional system, all dimensions are placed horizontally.

c. Without duplicating or crowding, indicate as many dimensions as practicable on the principal view; that is, the view which best shows the characteristic contour of the object. This rule is demonstrated in figure 4-94, where width dimension is placed on the top view, the height dimensions of the features are placed on the front view, and the depth dimensions are placed on the side view. The dimensions apply to one view only; that is, with dimensions between views, the extension lines should be drawn from one view, not from both views.

d. Do not place unnecessary dimensions on a drawing.

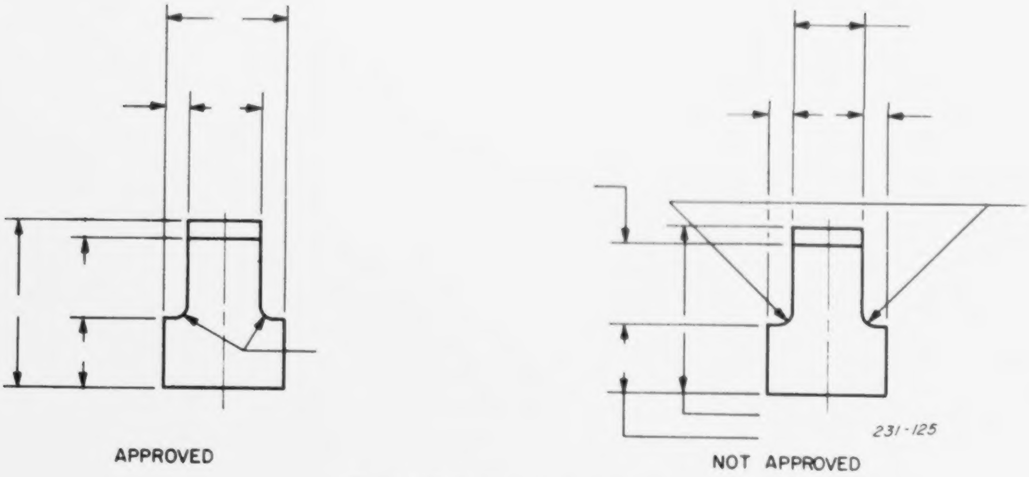


Figure 4-95. Dimensioning line arrangement.

This rule is also applied in figure 4-94. Notice that no dimensions are needed for the features on the right side of both front and side views because the other dimensions have already established these dimensions.

e. Whenever possible, avoid crossing one dimension line with another. As shown in figure 4-95, the best method of preventing crossed dimension lines is to place the dimension line of the shortest distance nearest the outline of the object and to add parallel dimension lines in the order of the size of distances dimensioned. When crossing dimension lines with extension or leader lines is unavoidable, make a break in the extension line or leader line at the point of crossing. However, when two extension lines cross, neither line is broken, nor are extension lines broken when they cross outlines.

f. Place dimensions by either the aligned system or the unidirectional system. The aligned system of dimensioning is used in figure 4-94. In this system, the dimensions parallel the surface they dimension. The unidirectional system is used in figure 4-93. Here all dimension values are horizontal.

g. Draw extension lines perpendicular to their related dimension lines unless increased clarity may be obtained otherwise. For an example of the exception, observe figure 4-96. The top illustration shows that inclined extension lines permit a much clearer presentation of the curved line than do the horizontal extension lines used in the lower illustration.

h. Keep parallel dimensions equally spaced. An example of this practice is shown at the upper right portion of foldout 2. The space between the outline and the first dimension line is slightly larger than the spaces between the dimension lines. The ratios 2 to 3 and 3 to 4 are commonly used. For example, if the spaces between dimension lines are one-fourth unit or three-eighths unit, the distance between the outline will be three-eighths or one-half, respectively.

i. Group related dimensions on the view showing the contour of a feature.

j. As shown in figure 4-97, arrange a series of dimensions in a continuous line. When this practice places the dimension values so close together that they are hard to read, stagger the values to form two columns, as shown in figure 4-98. This makes the numeral much easier to read.

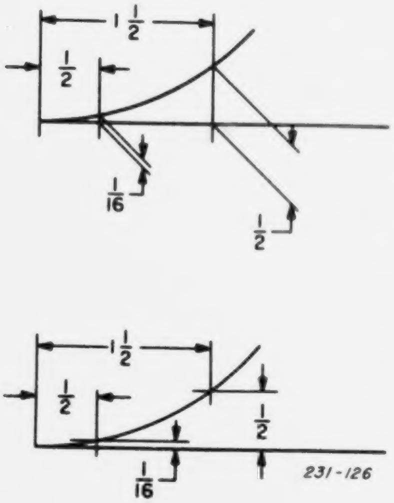


Figure 4-96. Use of inclined extension lines.

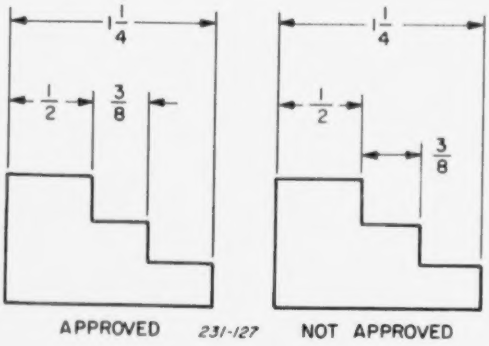


Figure 4-97. Grouping dimensions.

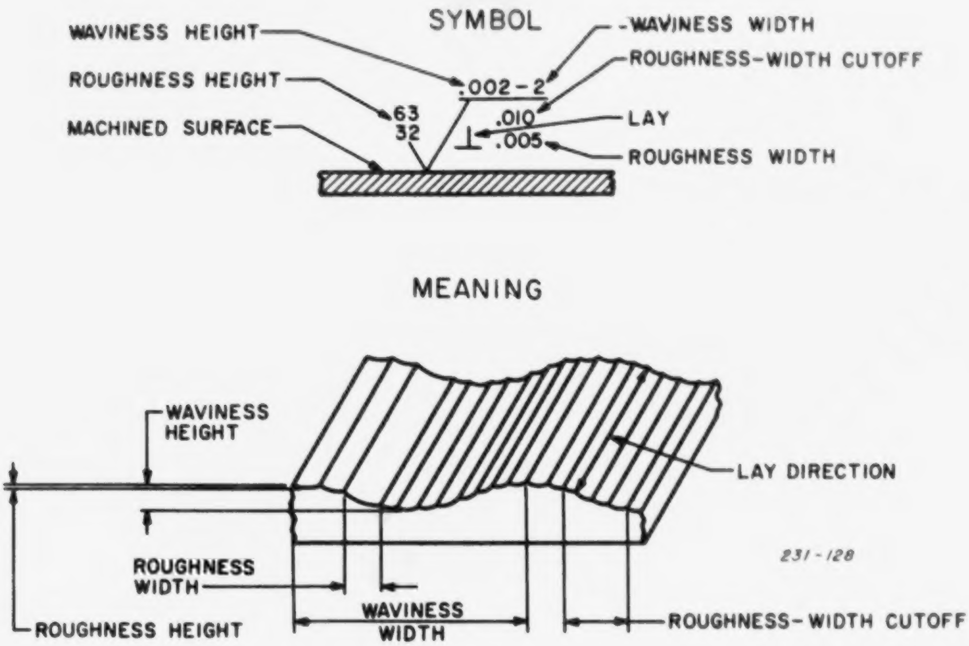


Figure 4-98. Surface roughness.

k. Place dimension values midway between arrowheads except when a center line interferes or when the values are staggered.

The following dimensioning practices have been so definitely established that they may be called rules.

a. Do not use an object line, extension line, or center line as a dimension line.

b. Always give location dimensions to the center of circles that represent holes, cylindrical projections, or bosses.

c. When dimension figures appear on a sectional view, show them in a small, uncrosshatched portion so that they can be read easily.

d. When an arc is used as a dimension line for an angular measurement, use the vertex of the angle as the center.

e. Show the diameter of a circle, never the radius.

f. Make dimensioning complete so that it is not necessary for workmen to add or subtract to obtain a desired dimension or to scale the drawing.

g. Place dimensions on the view that shows the distance in its true length.

Order of Dimensioning. A systematic order of working is a great help in placing dimensions. Foldout 2 illustrates the procedure. The steps are as follows:

(1) Complete the shape description.

(2) Place the extension lines and extend the center line where necessary. Plan for the location of both size and location dimensions. Study the placement of each dimension and make alterations, if desirable or necessary.

(3) Add the dimension lines.

(4) Draw arrowheads and leaders for notes.

(5) Add dimension values.

(6) Letter notes.

Although the preceding procedure on the order of dimensioning is simple, a beginning draftsman may have trouble with the first step, because the drawing of the shape description must be done to scale; that is, the distances such as those representing the width, height, and depth must be in correct relationship with each other, as indicated by the dimensions. To show you how this is accomplished, let's go through the steps of the process used to draw the shape description of foldout 2.

Before starting the actual drawing, mentally divide the object into its component geometric shapes, make a multiview sketch, and add size and location dimensions. Use this sketch as a model for the drawing. Make all construction lines light and use the following steps to make the drawing.

a. Establish a reference line for each view. Since the bottom surface of the object is machined and appears as a line in the front view, it is the logical choice for the reference line of the front view. The horizontal center line makes the best reference for the top view. Position these two lines on your paper so that the two views are properly spaced. These two lines serve as reference lines for vertical measurements.

b. On the top view, establish the vertical center line for the large hole. Then project it to the front view. These two lines serve as references for horizontal measurements.

c. Establish the position of the vertical center lines for the hole on the left and the two holes on the right by marking off from the vertical center lines distances of 2¾ units to the left and 1½ units to the right. Then draw the two vertical center lines in both views.

d. On the vertical center line of the two holes on the right,

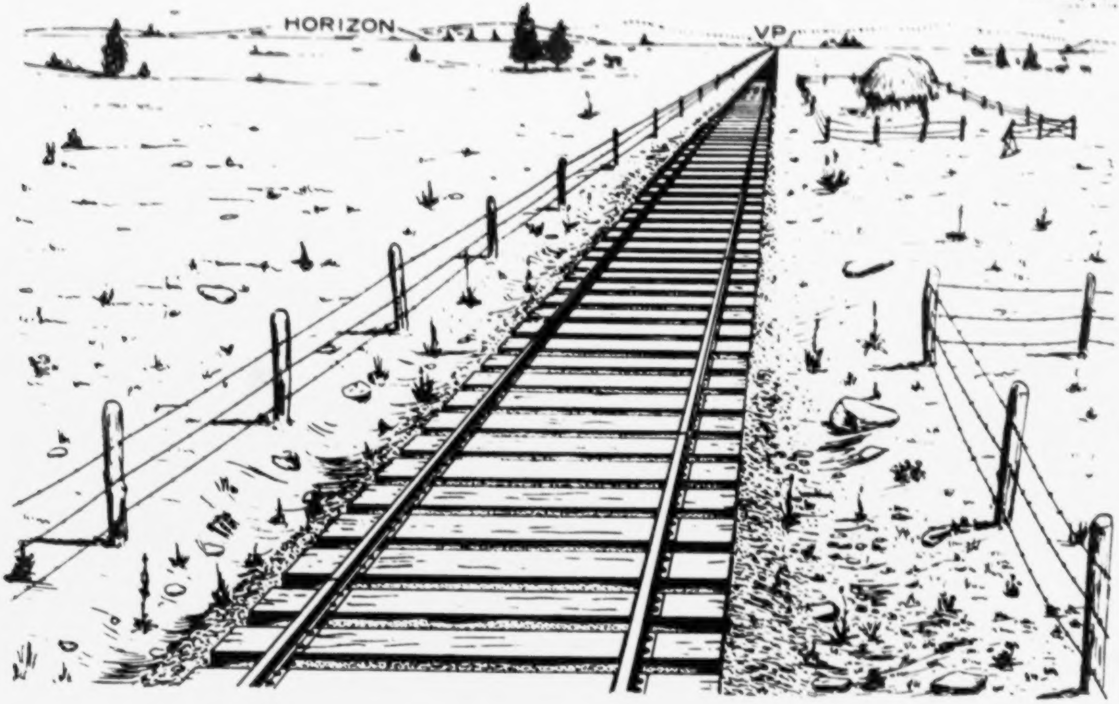


Figure 4-99. Vanishing point and horizon.

mark off the distance 7/8 of a unit to locate the center of the upper hole. From this center, mark off the distance 1 ¾ units to locate the center of the lower hole. Then draw the horizontal center lines through these two points.

e. Draw the forms that appear as circles in the top view, using 1/4 unit for the radius of the small holes, 17/32 unit for the radius of the large hole, 5/16 unit for the radius of the hole on the left, 1 unit for the radius of the large cylindrical form, and 3/4 unit for the radius of the small cylindrical form. Then, project the resultant circles to the front view.

f. Using the center of the hole on the left as the center and a radius of 1 ½ units, draw the rounded end of the object. Then project the left end of the object to the front view.

g. Draw the remaining edges of the object in the top view. The two edges that appear as horizontal lines are tangent to the semicircle which represents the rounded end of the object. The vertical line representing the edge at the other end of the object is located 4 ⅞ units from the left vertical center line. Then project the right edge to the front view.

h. In the front view, draw horizontal lines representing the heights of the different forms of the object, making the height of the base 1/2 unit, the height of the small cylindrical form 3/4 unit, and the height of the large cylindrical form 1 ¾ units.

i. In both the top and front views, draw the lines representing the web between the two cylindrical forms.

j. Draw all fillets and rounds, using a radius of 1/8 unit. This completes the construction part of the drawing.

k. Finish the drawing of the shape description by erasing all unnecessary construction lines and tracing over all lines, giving them correct weight and character.

Exercises (055):

1. What is the most important consideration in dimensioning practice?

2. Where should dimensions be placed on a drawing?

3. List the order of dimensioning.

4. How are rough surfaces dimensioned?

4-11. Perspective

Drawing a three-dimensional object on a two-dimensional surface is problematical. Children ignore such problems by drawing the objects as they know them to be, not as they appear. For example, when a child draws a house, he draws it as a rectangle (a square or oblong box form) and draws all the furniture in it. From his drawing, it would be very difficult to imagine how the actual house appears to a viewer. Unfortunately, perhaps, an illustrator is not often allowed a child's freedom. When he or she draws a house, he or she wants the observer to get an accurate image. Therefore, he or she cannot overlook the problems; instead, he or she uses a

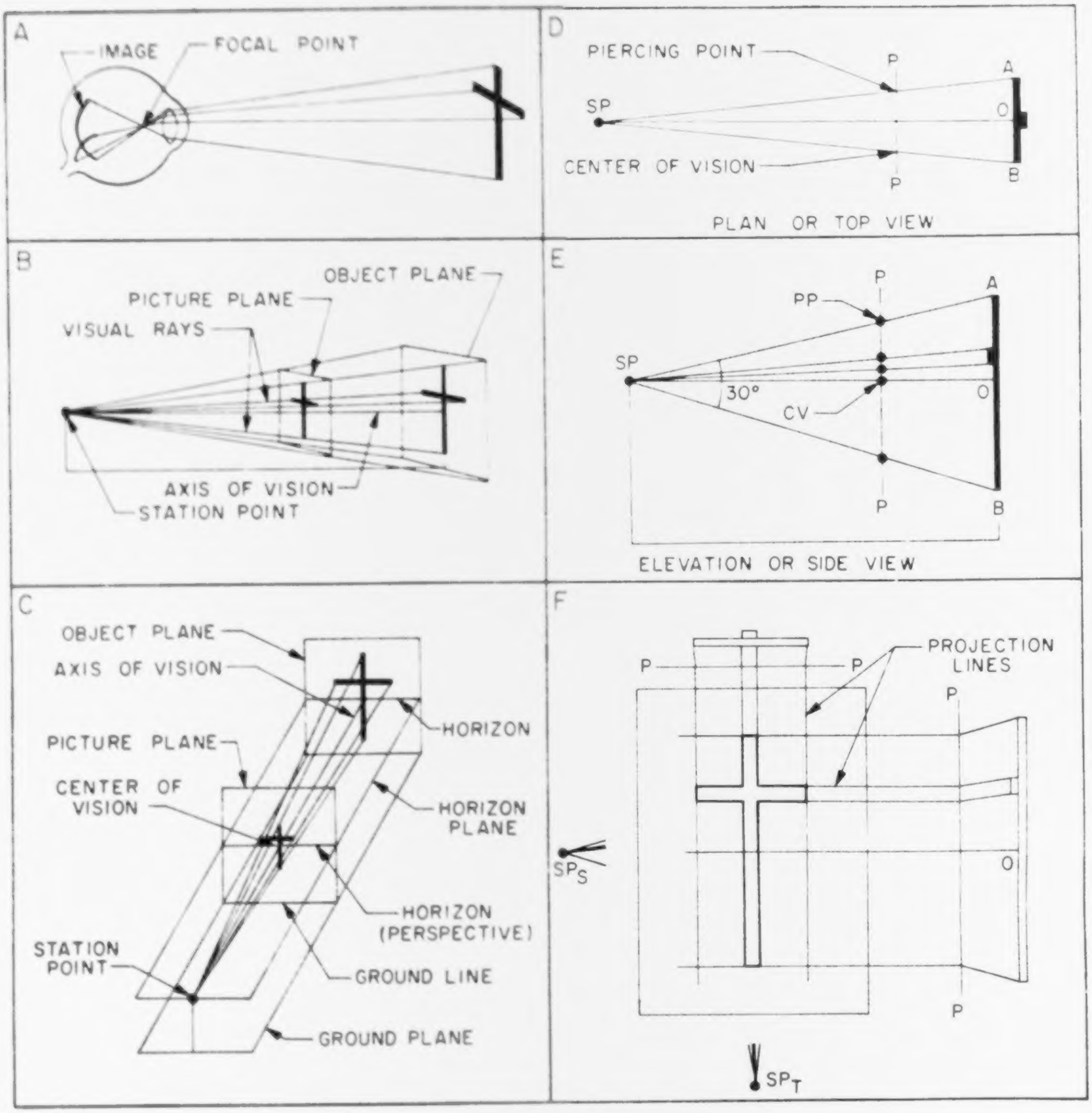

A
IMAGE
FOCAL POINT
D
PIERCING POINT
P
A
SP
O
CENTER OF VISION
P
B
PLAN OR TOP VIEW
B
OBJECT PLANE
PICTURE PLANE
VISUAL RAYS
AXIS OF VISION
STATION POINT
E
P
PP
A
SP
30°
CV
O
P
B
ELEVATION OR SIDE VIEW
C
OBJECT PLANE
AXIS OF VISION
HORIZON
PICTURE PLANE
CENTER OF VISION
HORIZON PLANE
HORIZON (PERSPECTIVE)
STATION POINT
GROUND LINE
GROUND PLANE
F
P
P
PROJECTION LINES
P
SP_S
O
P
SP_T

Figure 4-100. Perspective principles and nomenclature.

technique called perspective to make a two-dimensional drawing appear three-dimensional.

Like any graphics specialist, you need to know the basic principles involved in perspective drawing. We discuss these principles in this chapter. If you learn thoroughly the fundamentals of perspective, you will be able to apply them in your drawing; these principles will become automatic. Let us begin our study with the fundamentals of perspective.

056. Name and define each of the elements in a given illustration.

If you were looking out the observation window at the rear of a train, you might see a scene something like the one in figure 4-99. Why do some people have difficulty drawing such a scene? It is probably because they do not understand the principles of perspective on which such a drawing is based. If they draw a line slightly out of perspective, they do not know how to make it look right. By discussing how to make the illustration accurately reproduce what you might see, we can introduce you to the principles, terms, and definitions of perspective drawing. Before you can use the language of perspective, you must learn these fundamentals.

Perspective Principles and Nomenclature. One of the most important lines of perspective drawing is the *horizon*. It may be a visible line (as shown in fig. 4-99) that represents the actual horizon and the eye level of the observer, or it may be imaginary and not show at all. When the horizon does not show in the final picture, an imaginary horizon is used to establish both the eye level of the observer and the vanishing point (VP). The *vanishing point* is that point on the horizon toward which all lines representing parallel horizontal edges converge. Thus, in figure 4-99 the lines representing the rails and fences, which are parallel horizontal edges of the objects shown in the picture, converge to the single point, VP. Notice in the scene that only the horizontal lines that are not parallel to the picture plane (represented by the rectangular outline) vanish at VP. The lines representing the fence that runs parallel to the picture plane do not converge and are therefore drawn as parallel horizontal lines.

The *ground line*, which represents the intersection of the ground plane (surface of the ground) and the *picture plane* (rectangular outline), is another important line used in perspective drawing. Although we know the lines in the picture are all drawn on the same two-dimensional surface, only the points of these lines that touch the ground line appear to be in this plane. For example, only the parts of the two rails that touch the outline of the picture appear to be in the picture plane. The remainder of all of the lines appear to recede behind this surface. This is what gives the two-dimensional drawing the appearance of having three dimensions. Thus, the parts of the picture that touch the picture plane are the only parts shown true-size. All other parts appear smaller and smaller as we look back to the horizon. Since the ground line is in the picture plane, we can use it as a *measuring line* for establishing the relationship between parts of the picture. For example, if we know that the two rails of the railroad track are 4 feet 8½ inches apart, we can use the distance between the rails at the ground line as a unit of measurement to establish the lines of the fences on each side of the tracks. Of course, we will have to extend the ground line on each side so that we can measure the actual distance between the tracks and the fences. If we estimate that the fences are 30 feet from the tracks, then the measurement along the ground line from the tracks to the fence will be approximately six times the distance between the two rails.

Now let's study some of the principles of perspective drawing. As shown in figure 4-100,A, when a person looks at an object, light rays reflected by the object are focused by the lens of the eye so that they pass through a focal point and strike the spherical rear surface of the eye, forming an inverted image. This is a perspective image, since it has only two dimensions; yet it appears to have three. The closest we can come to duplicating this process by pictorial means is by drawing the object in perspective.

The simplest method of making a perspective drawing that looks like the object is to make a tracing on a piece of glass. That is, you place a pane of glass between you and the object and use a suitable marking tool such as a grease pencil to trace all visible edges of the object. But this method works only if you have some means of holding the glass, and you don't move your head while making the drawing. However, even though this method is rather impractical, it does illustrate some of the principles of perspective.

Note the similarity between the illustrations in figure 4-100,A, and figure 4-100,B. In both, light rays that converge at a single point determine the prominent points of the perspective image. If we moved the pane of glass to the other side of the *station points*, which represents the eye of the observer and the point through which the rays are not passing, and blocked out all other light rays, an inverted image would be produced just as the one in figure 4-100,A, so you can see the same principles are used in both illustrations. Now, let us go over the illustration in figure 4-100,B, to learn other terms and their definitions.

One of the most important terms of perspective drawing is *station point*. It is the point through which all converging light rays (called *visual rays* in perspective drawing) pass. Actually, the station point represents the position of the observer's eyes in relation to the object. The position of the station point greatly influences the perspective; if it changes, so does the perspective change accordingly.

In figure 4-100,B, the station point is located directly in front of the object. If the observer moves some distance to his or her left, his or her line of sight is at an angle to the object plane (one of the object's surfaces), and naturally, the object appears different. The observer is able to see the left side of the object as well as its front surface. Moving to the right, upward or downward, has a similar effect. Moving nearer or farther away makes the object appear larger or smaller. Since the position of the station point is so important, it is one of the first things to establish when you make a perspective drawing. You will see how this is done after we discuss other important terms shown in figure 4-100,B, and 4-100,C.

The picture plane is another important element in perspective drawing. As we said before, the picture plane can be real or imaginary. In figure 4-100,B, it is the surface of the pane of glass on which the perspective is drawn. Since we seldom draw a perspective this way, we sometimes imagine the picture plane in this position, but use the drawing paper as the picture plane. We always consider the surface of the picture plane to be perpendicular to the observer's line of sight and to the horizontal ground plane.

In the language of perspective, the observer's line of sight (*centerline of vision*) is known as the *axis of vision*. Since the axis of vision and the ground plane are both perpendicular to the picture plane, the axis of vision is parallel with the ground plane. The axis of vision is represented in figure 4-100,B, by a horizontal line drawn from the station point to the object and, as you can see, it is drawn parallel to the ground plane and perpendicular to the picture plane. The point at which this line intersects the picture plane is called the *center of vision*.

Now look at figure 4-100,C. This figure shows the four planes involved in perspective drawing. Two of these are vertical planes and two are horizontal planes. We have already discussed the picture plane and the object plane in figure 4-100,B. Let us add some information about the object plane before we discuss the two horizontal planes.

The *object plane* represents any vertical surface of the object. In the case of the illustration shown, it represents a wall on which a cross is attached. An object plane can be perpendicular or oblique to the axis of vision, depending on its position in relation to the station point.

Since the ground plane and horizon plane are both horizontal planes, they are always parallel to each other. The ground plane represents the surface of the earth, while the *horizon plane* represents an invisible plane passing through the station point and the earth's horizon. The important fact about these planes is their intersection with the picture plane.

The intersection of the ground plane and the picture plane forms the ground line, which we have already discussed. The intersection of the horizon plane and the picture plane forms a line called the horizon.

If we were to place our drawing paper in the same position as we placed the pane of glass in figure 4-100,B, and 4-100,C, we could not see the object; we must therefore use some other method of drawing an object in perspective. The principles of various methods of drawing perspective are illustrated in figure 4-100,D, E, and F.

To draw a three-dimensional object on a two-dimensional surface, you must know the shape and dimensions of the object. The best ways of using this information is to make two-dimensional drawings of the plane and elevation views of the object. Parts D, E, and F of figure 4-100 show the principles involved in using these views to locate the prominent points on the picture plane. After establishing these points on the picture plane, you can draw the perspective.

We establish the prominent points on the picture plane by drawing visual rays between the station point and all prominent points on the object and finding where these visual rays pierce the picture plane. Notice how clearly D and E of figure 4-100 show the points at which the visual rays intersect the picture plane. The reason for this is that our line of sight is perpendicular to the edge of the picture plane in both top and side views. For this reason, we can also take direct measurements between the points of intersection, which we call the *piercing points*, to establish the width and height of our perspective as well as all other prominent points. (Piercing points, to say it another way, are the points where line of vision intersects with the picture plane.)

A much easier method of establishing the prominent points of the perspective on the picture plane is to position the top and side views as they are shown in figure 4-100,F. The top view is placed above the drawing paper so that the picture plane, P-P, is parallel with the top edge of the paper. The side view is placed to the side of the paper so that its picture plane, P-P, is parallel with the vertical edge of the paper. After drawing visual rays to the station point in each view, you draw vertical projection lines from the piercing points in the top view and horizontal projection lines from the piercing points in the side view. The intersections of the projection lines from the corresponding piercing points in both views establish the prominent points of the perspective on the drawing paper. To draw the perspective, you draw lines between the appropriate points.

Before we leave figure 4-100, let us use it to show how important the position of the picture plane really is. Actually, there are two aspects of its position to consider. The distance between the picture plane and the object affects the perspective. The perspective is also affected by the angle between the picture plane and the object. In our examples, we used the simplest angular position. In fact, to simplify our explanations, we eliminated any angular position altogether by placing the picture plane parallel to the object plane.

The distance between the picture plane and the object affects the size of the perspective. Use figure 4-100,D and E, to visualize what would happen if we were to move the picture plane further from the object (closer to station point). You can see that this would reduce the perspective even more. As we move the picture plane closer to the object, the perspective becomes larger since the picture plane intersects the visual rays at points nearer the object. If we wanted the perspective of the front surface of the object to be true size, we would place the picture plane right on the object plane. If the object was small and we wanted our perspective drawing to be an enlargement, we would place the picture plane beyond the object. You can visualize the arrangement if you imagine that the object and picture planes in figure 4-100,B, are reversed in position.

Positioning the picture plane at an angle with the object complicates the perspective drawing. Since we must keep the axis of vision perpendicular to the picture plane, we must also change the position of the station point. When we do this, we see one side and possibly the top or the bottom surfaces of the object as well as the front surface. This will make it necessary to use a different type of perspective drawing.

Since the position of the station point has a great effect on perspective, let us find out where the station point should be placed. Of course, its position depends on the effect you desire. If you place the station point close to the object, the corners of the perspective will be sharp, and your perspective will appear distorted. Actually, the farther you place the station point from the object, the more lifelike your perspective will appear. However, it is impractical to place the station point so far from the object that it is not on your drawing paper or table.

In figure 4-100,E, the station point is placed so that the largest angle between any two visual rays is equal to 30°. This is a good rule to use in placing the station point, since it gives an interesting perspective without too much distortion. A simple, practical way to establish the station point using this 30° rule is to first draw the line representing the axis of vision (which you know is perpendicular to the picture plane and is level with the horizon). Then, using the view with the widest span, slide the 30° corner of a 30° to 60° triangle along this line until the edges of the triangle just touch the outermost points of the top or side view. The tip of the triangle establishes the position of the station point. Since the side view of the object had the widest span, we used it to establish the position of the station point, SP, in figure 4-100,E. Then, we placed the SP in figure 4-100,D, at the same distance from the picture plane. If you have a triangle handy, try this method on the station point shown in figure 4-100,E, and see how it works.

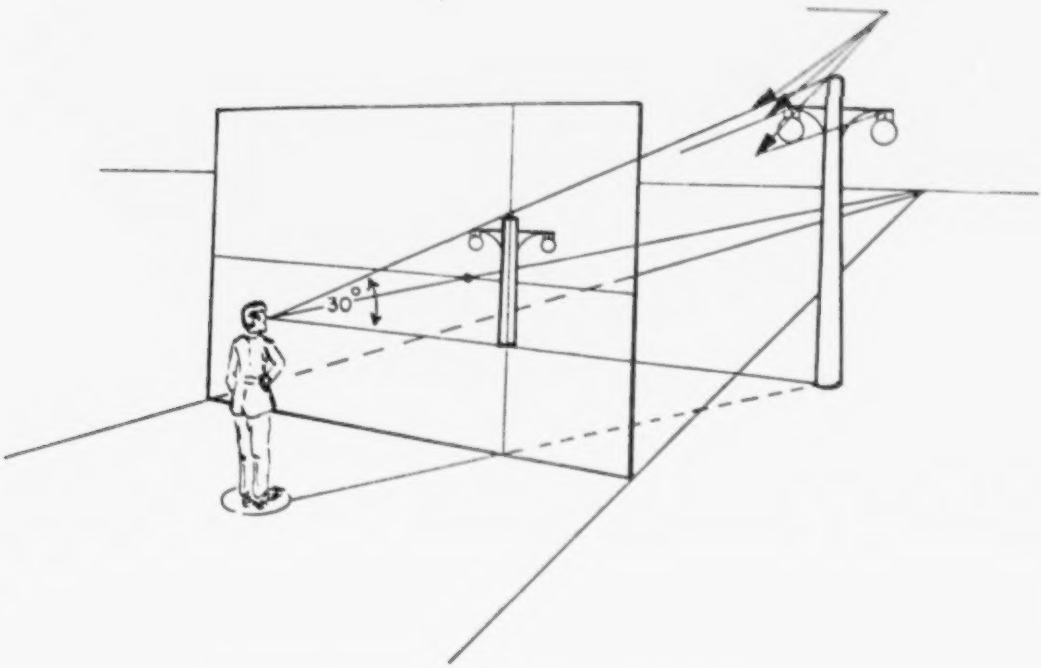


Figure 4-101. Perspective nomenclature (objective 057, exercise 1).

Exercises (056):

1. Using figure 4-101, which shows various unnamed elements of perspective, write in the appropriate term for each (from the following list).
   a. Horizon.
   b. Vanishing point (VP).
   c. Ground line (GL).
   d. Picture plane (PP).
   e. Station point (SP).
   f. Visual rays (projectors).
   g. Centerline of vision (CV).
   h. Object plane.
   i. Horizon plane.
   j. Measuring line (ML).

2. Define each of the above terms.

3. Why does the station point critically affect perspective?

4. How does the distance between the object and the picture plane affect perspective?

057. Name and briefly define the three types of perspective, and label each of the respective types in a given figure.

Types of Perspective. Perspective drawings are one-view drawings in that one view shows a three-dimensional object in a definite proportional relationship. While perspective drawings do not show an object in its true shape and dimension, they do show how the object looks from that point of view.

Parallel perspective. Parallel (one-point) perspective occurs when two dimensions are parallel to an imaginary plane of reference called the picture plane.

Figure 4-102 is a one-point perspective projection of a cube from a top and side view in orthographic projection. The technical terms used in discussing perspective projection are appropriately displayed in the figure.

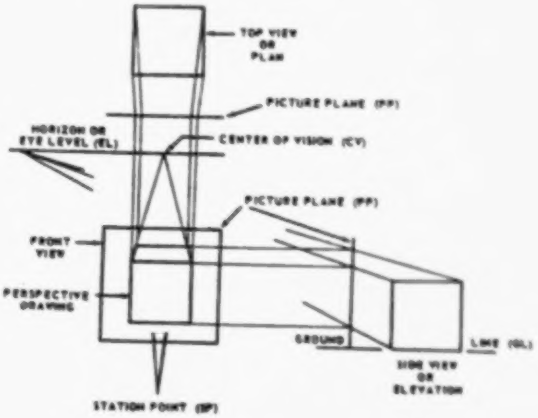

TOP VIEW
OR
PLAN
PICTURE PLANE (PP)
HORIZON OR
EYE LEVEL (EL)
CENTER OF VISION (CV)
PICTURE PLANE (PP)
FRONT
VIEW
PERSPECTIVE
DRAWING
GROUND
LINE (GL)
SIDE VIEW
OR
ELEVATION
STATION POINT (SP)

Figure 4-102. One-point perspective drawing.

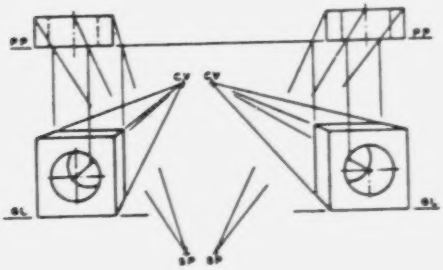


Figure 4-103. Position of station point.

Notice that the picture plane becomes a line in the top and side orthographic views. Projectors from the corners of the top view are drawn converging toward the station point; but, from the points where the projectors, or visual rays, pierce the picture plane, parallel projectors are drawn down to the perspective view.

The station point for the side view is actually the same station point as that shown for the top view. It is, therefore, the same horizontal distance from the cube, but its elevation shows the height of the station point above the level of the cube. The picture plane in the side view is also the same distance from the cube as in the top view, and the ground line in this view, on which the picture plane rests, defines the ground line of the picture plane in the perspective drawing.

In the side view, projectors are drawn converging to the station point, and at their piercing points on the picture plane, parallel horizontal projectors are drawn to the perspective drawing. The intersection point of a projector from a corner of the cube in the top view with the projector from the same corner in the side view locates the corner in the perspective drawing.

Notice that the center of vision in this drawing is located directly above the station point in the perspective drawing and on the same line with the station point for the side view of the cube.

The center of vision defines the point at which all lines perpendicular to the picture plane in the perspective drawing converge. It is also called parallel perspective because the front face of the object is parallel to the picture plane.

In parallel perspective drawings, the center of vision is not necessarily centered on the object. It may fall to one side or the other as shown in figure 4-103. However, when the front face is parallel to the picture plane and the center of vision is at one side of the drawing, there will necessarily be some distortion. Actually, the drawing becomes an oblique projection and not a true perspective drawing. Notice that, in order to make such a drawing, the object must be considered as resting with its front face against the picture plane. If this were not so, converging projection lines from the corners of the front face would alter its appearance so that it would no longer appear to be parallel with the picture plane. In fact, as you will see, it would then become a two-point, rather than a one-point, perspective drawing.

Two-point perspective. The second type of perspective—two-point—is the most commonly used for making perspective drawings. In two-point (angular) perspective, the object is considered as sitting at an angle to the picture plane. In the perspective drawing of such an object, there are two sets of horizontal edges converging toward two different vanishing points on the eye level or horizon line. The parallel lines that slope to the right will vanish at a point in the distance called the right vanishing point (VPR), and those that slope to the left at a point called the left vanishing point (VPL) (see fig. 4-104).

In the figure, the top orthographic view of the block was drawn first. The position of the picture plane was then determined.

When the corner of the object rests against the picture

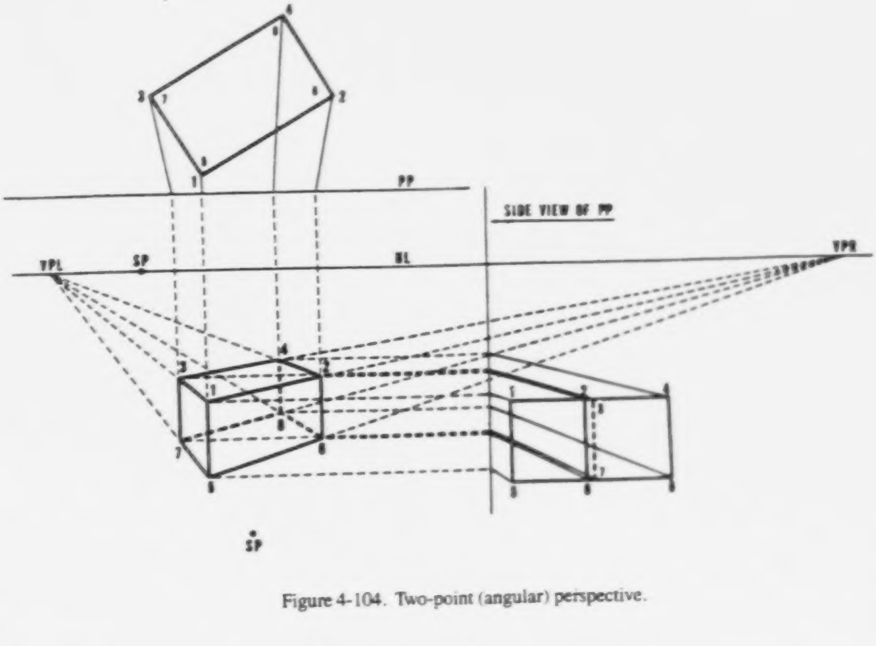


Figure 4-104. Two-point (angular) perspective.

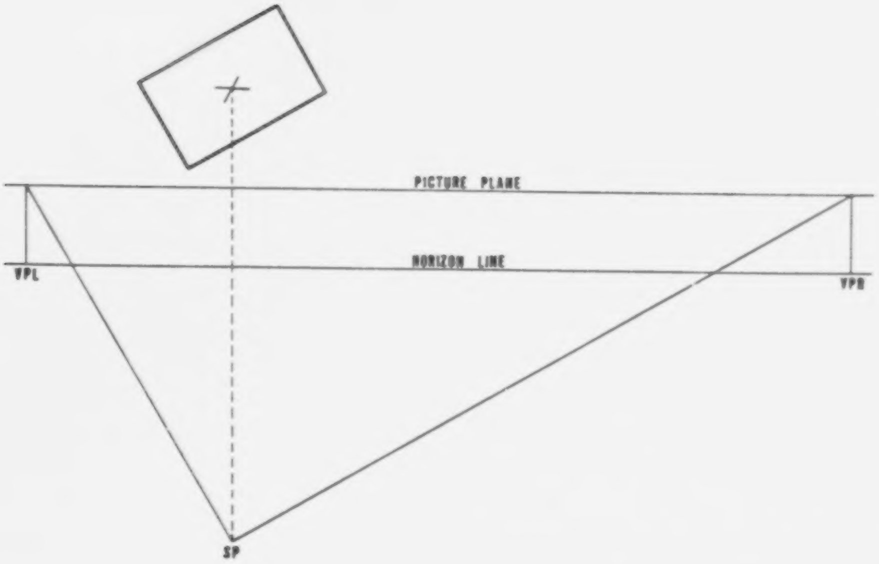


Figure 4-105. Locating vanishing point.

plane, the vertical line representing the corner in the perspective drawing will be full size (just as in one-point perspective, where the front face is full size if it rests against the picture plane). In any perspective drawing, the comparative sizes will be reduced proportionately as the distance is increased between the picture plane and the object.

Once the picture plane was established, the station point for the top view in figure 4-104 was located approximately opposite the center of the block. The distance from the station point to the object should not be less than twice the width of the object.

When this rule is neglected, a distorted appearance may result in the perspective drawing. There is a cone of about 30° in which the human eye sees clearly. For this reason, the angle formed by the lines of sight from the sides of the object to the station point should not exceed 30°. In no case, even when the perspective drawing depicts a panoramic scene, should it exceed 45°.

Next, the picture plane for the side view was established.

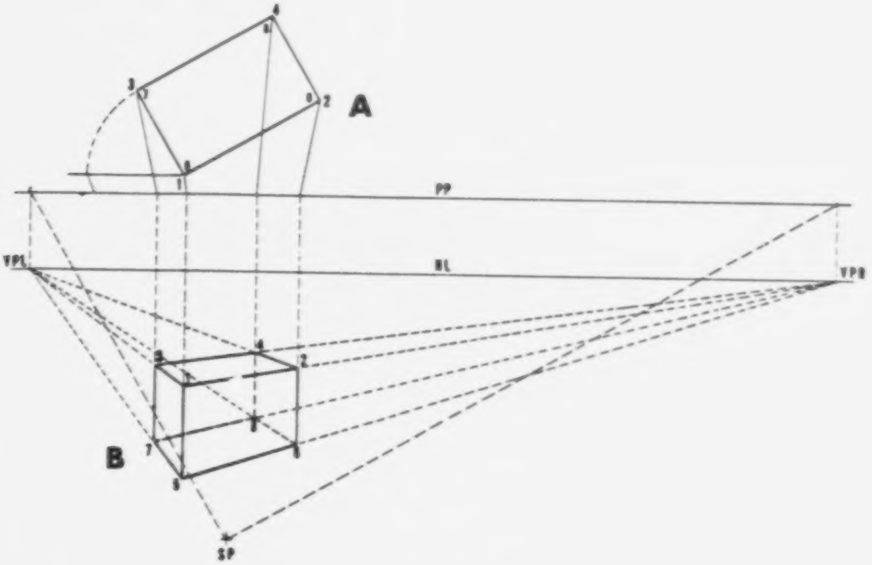


Figure 4-106. Two-point (without elevation of object).

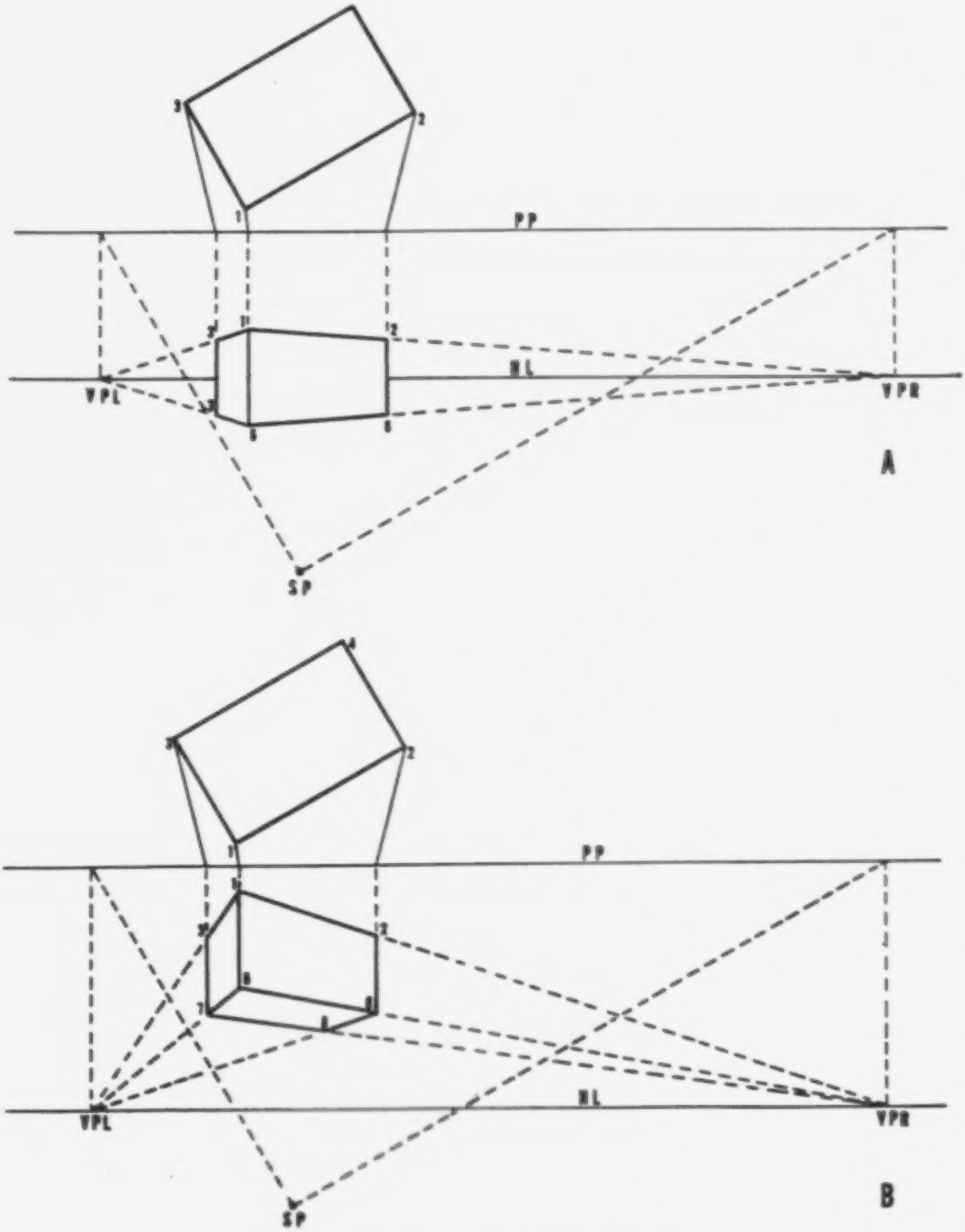


Figure 4-107. Object on eye level (A), object above eye level (B).

Then the side view was drawn. (Points may be projected from the top view if necessary.) Remember that the picture plane in the side view (elevation) is the same picture plane shown in the top view and, thus, it is the same horizontal distance from the object.

The station point for the side view was located next. This station point is the same point seen in the top view and, therefore, it is the same horizontal distance from the object. However, its angle to the object can vary. This variation of the station point in the side view determines the height of the eye level or horizon line. Note that the station point for the side view always falls on the horizon line.

This horizon line is a very important one. If it is high, objects in the perspective view will appear as if they were viewed from a height. If it is low, objects will appear as if they were viewed from directly in front or below. Generally,

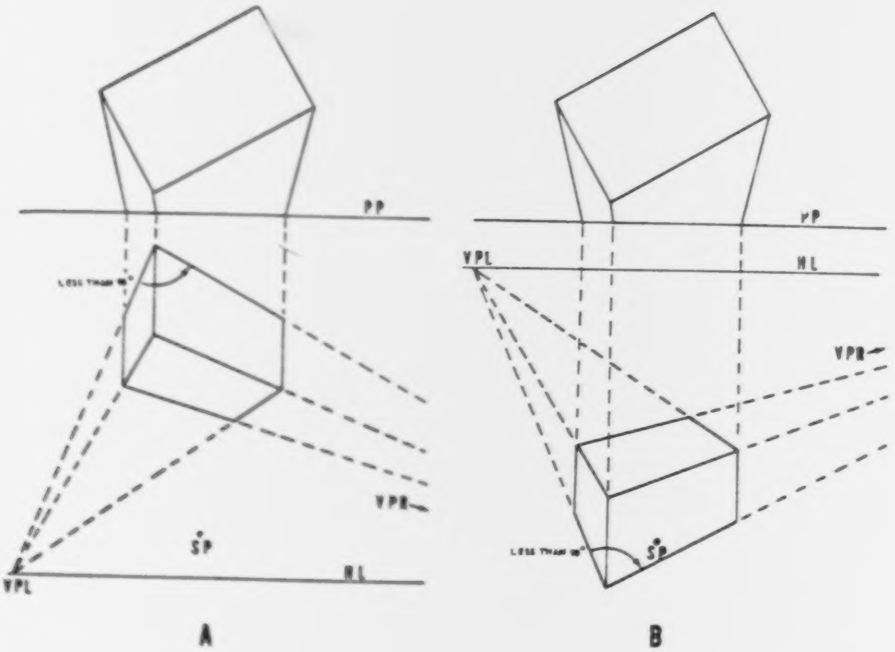


Figure 4-108. Perspective distortion.

it is best to select a station point approximating that from which a real observer might view the object.

This method is usually used when architectural drawings are made in two-point perspective. However, two-point perspective may be drawn (as in fig. 4-104) from a plan view of the object alone, without the elevation. When this is done, the vanishing points are first projected on the picture plane and then located on the horizon line. In order to do this, a line parallel to one set of horizontal lines in the top view is drawn from the station point to the line of the picture plane. The point at which this line intersects the picture plane is then projected to the horizon line to locate a new point, either VPL or VPR (see fig. 4-105).

When this method is carefully used, it will produce as much accuracy as the method illustrated in figure 4-104. For example, in figure 4-106, the horizon line has been placed at the same level as the horizon line in figure 4-104, and the cube is the same size so that the two methods can be compared. In figure 4-104, the vanishing points were found after the drawing was completed, and it was not necessary that they be found at all. In figure 4-107, the vanishing points were found at the start, because they control the drawing.

In figure 4-107 lines are drawn converging toward the station point from the corners of the block in the top view. From the points where these lines pierce the picture plane, verticals are dropped to give the apparent width of the block in the perspective view. Since an elevation is not used, the various heights cannot be found directly. However, the bottom of the block (B) may be located, as shown in figure 4-107, by drawing lines to the vanishing points from the point selected as the near corner.

Now if the perspective height of any one vertical line can be determined, the height of the other verticals can be found automatically. This is easy to do when one edge of the object rests against the picture plane. This edge will then appear in its true height in the perspective view. If you have the dimension for this height in the orthographic projection (A), you can transfer that dimension directly to the perspective view (B). Lines drawn to the vanishing points from this top corner will locate the top of the two sides (3-1, 4-2 B). Lines drawn to the vanishing points from the far corners on these sides will complete the drawing of the block.

Still discussing figure 4-107, B, when the front edge of the subject does not rest against the picture plane, it is necessary to use some other dimension. Because the end of the block is square, it is possible to find the perspective length of a horizontal line and use this dimension for the edge of 1-5. This is done by drawing a line parallel to the picture plane from point 1, measuring a length of this line equal to 1-3, and drawing a line converging on the station point to the picture plane from the end of this line.

This length can then be transferred to the front edge of the perspective view (B) and the view completed as shown in figure 4-106. To check the accuracy of this method, compare figure 4-106 with figure 4-105. You will find that, since the station point, horizon level, and bottom of the cube correspond, the two perspective views are similar. It is possible to make them correspond exactly.

In figure 4-106, the bottom of the front edge of the block (B) has been placed arbitrarily at a certain point. Actually it could have been placed on the vertical projection from the cube at any desired point. Thus, the perspective view may be drawn below the eye level, or, as shown in figure 4-107, it may be drawn at eye level (top) or above it (bottom).

However, if the object is placed too high above the eye level or too low below it, the effect will be one of distortion. A block drawn in these positions will cease to look right as shown in figure 4-108. When the station point is too close to

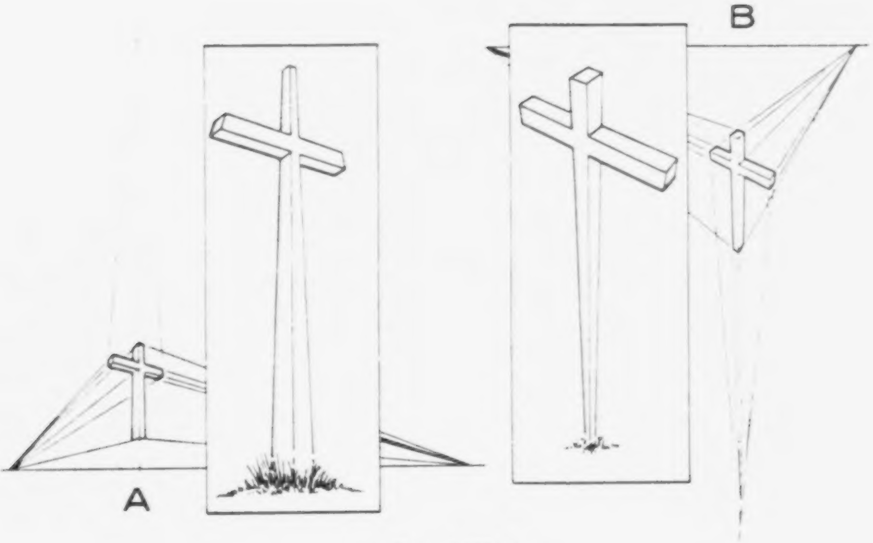


Figure 4-109. Cross.

the object, there will be a similar distortion. The angle indicated in the figure should never be less than 90° and preferably not more than 100°.

To overcome distortion such as that illustrated in figure 4-108, the station point may be moved further from the object, or the picture plane may be tilted so that a third vanishing point is needed for the third set of parallel lines in the drawing.

Three-point perspective. Oblique, or three-point, perspective occurs when none of the object's surfaces are parallel to the picture plane. Three-point perspective is usually needed when the station is close to the object and the picture plane is at an angle to the horizon line as shown in figure 4-109. Looking up at a tall building, large trees, or the cross pictured here can produce such a situation. The horizon in this case is usually very low, or entirely below the object being viewed (fig. 4-109,A). If you were looking down from above (fig. 4-109,B), the horizon may or may not appear in the view at all.

A general rule to follow in a case like this is: small objects look better if the three vanishing points are well separated. The perspective angle should not be acute. To emphasize the bigness of an object, sharp diagonal lines are important. Here the closeness of the vanishing points strengthens the bigness effect.

Be sure that the horizontal lines end at the eye level line, because one cannot be higher or lower than the other. Regardless of their distance apart, they must be established on the same eye level. In any perspective drawing, it is a good idea to use the sketching method and lightly sketch the object before finding the horizon line and vanishing points.

Exercises (057):

1. Name and describe each of the three types of perspective.

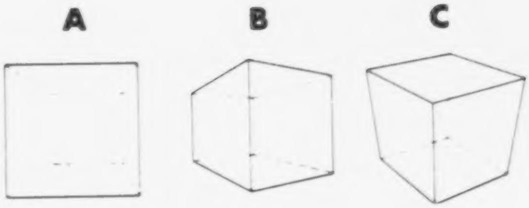


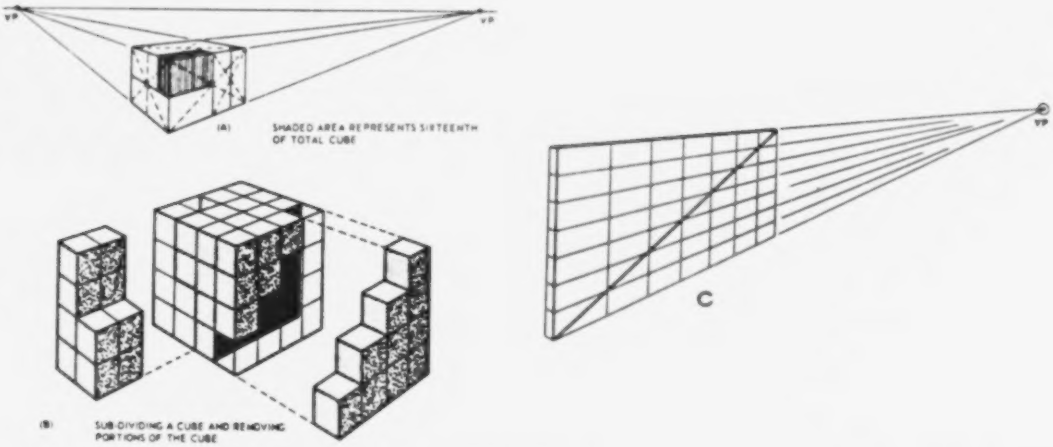
Figure 4-110. One-, two-, and three-point perspective (objective 058, exercise 2).

2. Using figure 4-110, specify which types of perspective A, B, and C are?

058. Using two-point perspective and receding plane given in an exercise figure, divide a rectangular area into uniform patterns; then state the two steps necessary before measuring.

In drawing any form, the proportions should be correct. This is especially true when drawing form in perspective. At the beginning of this chapter, we introduced into our discussion the cube—the basis for all good drawing. In order to solve many practical problems in art, you must become acquainted with methods of measurement as they apply to this geometric solid. Here are a few of those methods.

Measurement. Before making measurements of any kind, establish the needed vanishing points and station point. Next, correctly sketch in the overall shape of the object. If you do not, you may wind up making endless corrections, and the drawing will never be quite right artistically. To divide a rectangle or a square, draw a diagonal line from



(A) SHADED AREA REPRESENTS SIXTEENTH OF TOTAL CUBE

(B) SUB-DIVIDING A CUBE AND REMOVING PORTIONS OF THE CUBE

Figure 4-111. Division.

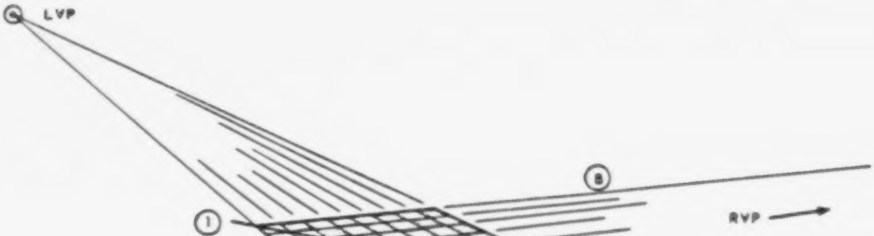

LVP
B
1
RVP
2
A
VP

Figure 4-112. Division of a rectangular area.

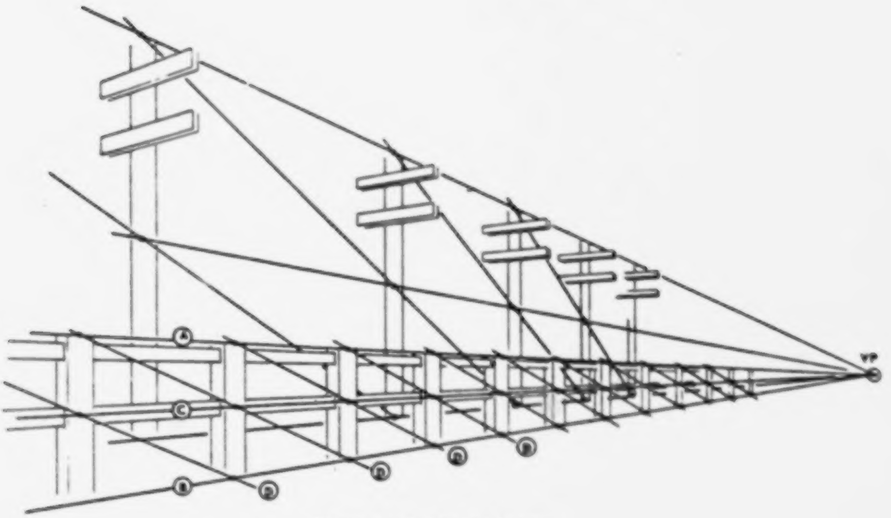


Figure 4-113. Vertical division.

corner to corner as shown in figure 4-111,A. The point where the diagonals cross is the center of the rectangle or square. This simple rule is invaluable—it enables you to solve problems that are seemingly unsolvable.

At other times it is necessary to divide an area, or a diagonal, into a number of parts. Here a ruler alone will not suffice. As with most division of space, the vertical (fig. 4-411,C) or horizontal line (not shown) parallel to the picture plane is the key. Aspect B of figure 4-411 shows the subdivision of a cube, portions removed. For example, to divide a receding plane into any number of units, divide the left vertical height into the desired number of parts with a ruler as shown in figure 4-411,C. Draw lines from the points of division on the vertical line out to the vanishing point. Then draw a line from corner to corner as shown, and the intersections of the diagonal and the horizontal lines drawn to the vanishing point are the correct points to add the other vertical lines.

Figure 4-112 shows the correct method of dividing a rectangular area into uniform rectangular patterns, such as floor tiles. The width of the squares are first measured on a horizontal line (A). Two vanishing points are established and lines are drawn from the divided horizontal line to the left vanishing point, then the depth is established by drawing lines to the right vanishing point. A diagonal line is drawn from corner to corner, points 1 and 2. Where the diagonal intersects the lines drawn to the left vanishing point are the correct points for the receding lines to be drawn to the right vanishing point. Notice that the lower drawing is a one-point perspective.

Figure 4-113 shows the method for drawing vertical divisions of posts, telephone poles, or any object with evenly spaced units. First draw two posts any distance apart. Locate the vanishing point by drawing lines (A) and (B) from the two original posts. At no time should any posts extend above or below the receding lines. Locate the center of the first post, then draw a line through the center point of the first post to the vanishing point on the horizon. From the top of the first post, draw a line through the center of the second post. the third post will be located where the diagonal line touches line (B). Repeat this procedure as many times as you desire, doing one at a time.

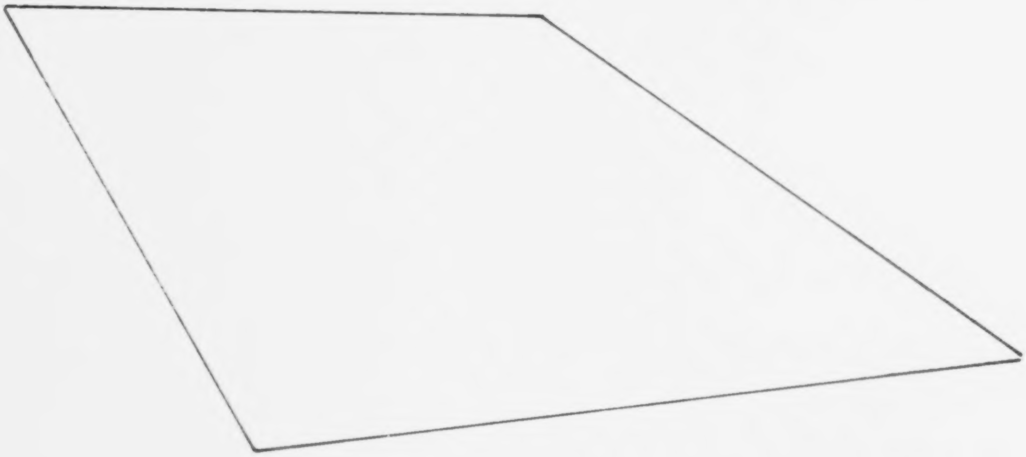


Figure 4-114. Exercise rectangle (objective 059, exercise 1).

Exercises (058):

1. Using figure 4-114, divide the area into 25 uniform shapes (like floor tiles).

2. What are the two steps necessary before making measurements?

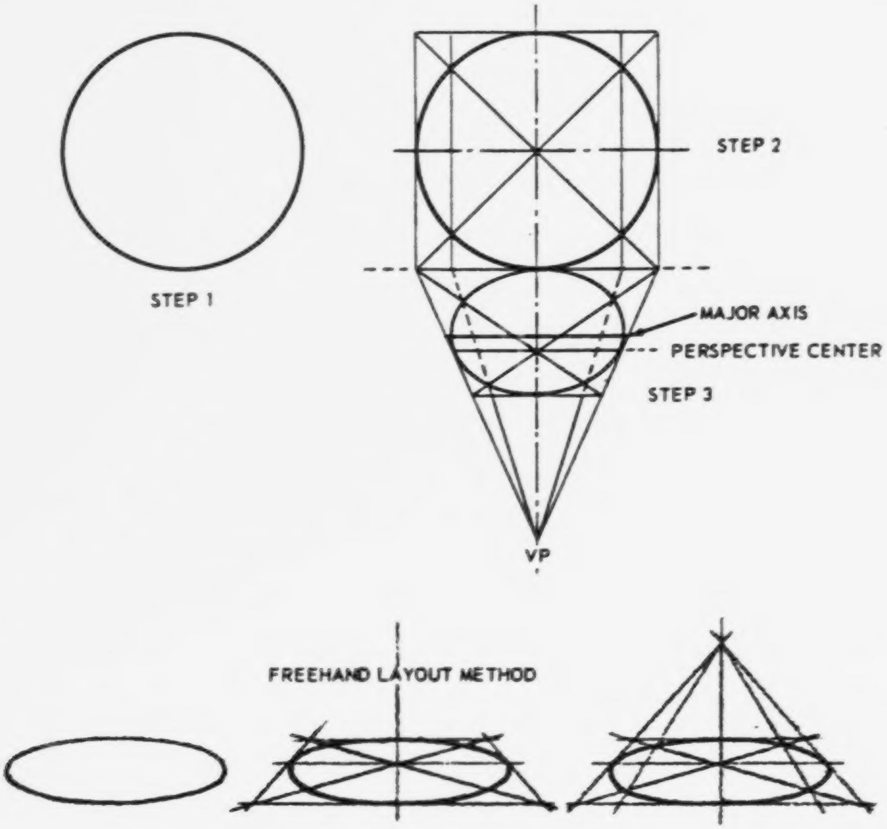

STEP 1
STEP 2
MAJOR AXIS
PERSPECTIVE CENTER
STEP 3
VP
FREEHAND LAYOUT METHOD

Figure 4-115. Mechanical tool and freehand layout methods.

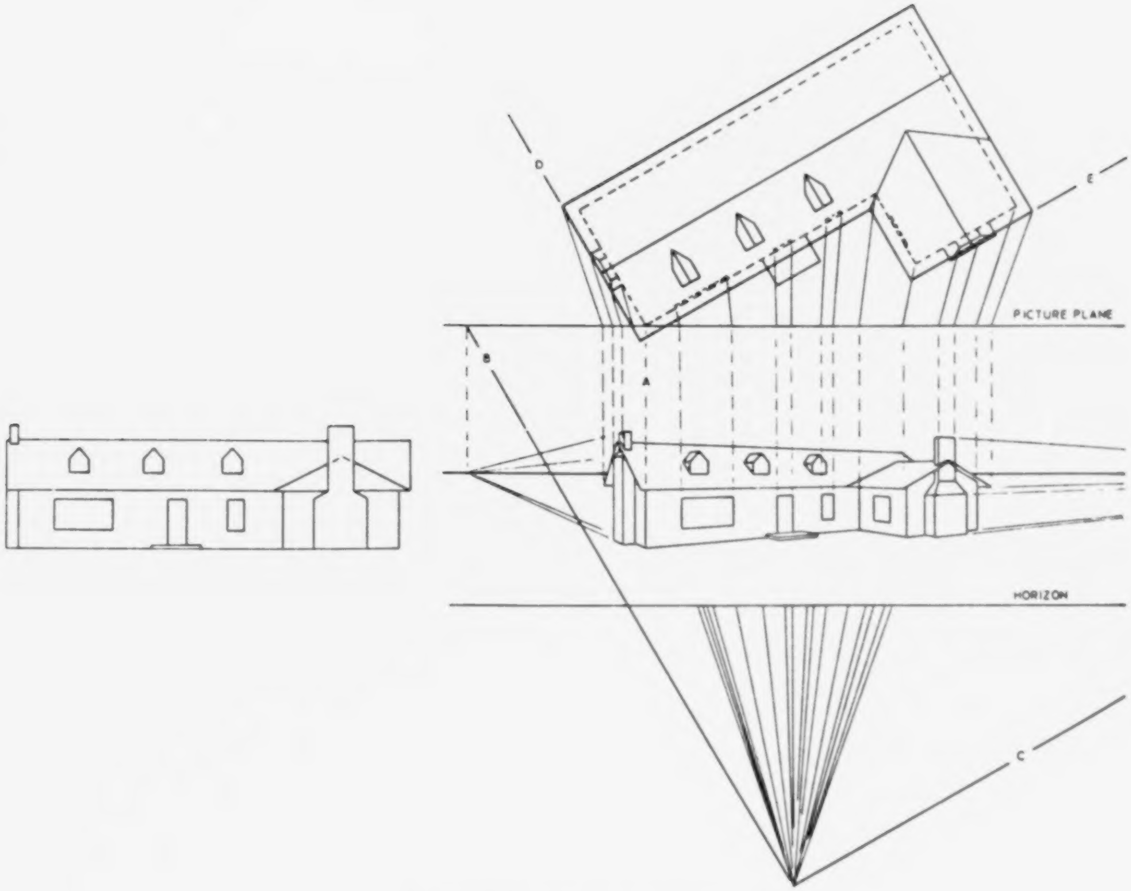


Figure 4-116. Plan and elevation views.

059. Given the requirements, draw two circles in perspective—one in freehand, the other in instrument layout.

The Cube and Circle. The cube is in many ways the most important single shape you will study in your art career. Both simple and complex structural development can be illustrated by this one geometric form. Its importance will become increasingly evident as you work with three-dimensional forms and measurement, especially when you draw objects in perspective. As the preceding text segment pointed out, in order to solve many practical problems in perspective, you will use the cube or some portion of it as a medium of measurement. This may be a tedious business because you may make several sketches before you get an acceptable drawing. But it is time and effort well spent. Some artists who make cubes too wide or too narrow have never really learned what a square—hence a cube—looks like in perspective.

Although the cube is perhaps the most important shape, the circle is the guide for drawing all two-dimensional curves, ellipses and ovals in perspective. Even so, its basis is the square, or one surface of the cube. The square is used because there are no direct measurements on a curve in perspective. Vanishing points are determined from the square, and proportions of the curve can easily be seen within the square. Figure 4-115 shows the proper layout of a circle in perspective. The first step in the instrument layout is to draw a circle with the desired dimensions. Second, draw the square around the circle and add the diagonal and centerlines as shown in step 2. This will give you eight checkpoints for drawing the circle in perspective. Next, draw the perspective lines back to the desired vanishing point to establish the square in perspective.

The back line of the new square is determined by the method presented in figure 4-115. Now diagonal lines are drawn from corner to corner in the perspective square. Within the original square, short vertical lines are drawn downward to the picture plane from the points where the circle line and the diagonal lines intersect. From these two points, draw lines back to the vanishing point. The points at which these lines cross the diagonal lines in the perspective square are the points through which the curve is drawn.

The center of the circle shifts from the center of the square when the circle is in perspective. The intersection of the diagonals is the perspective center; the intersections of the horizontal centerline with the lines drawn back to the vanishing point does not indicate the widest part of the circle in perspective.

When drawing circles in perspective, it is often best to rough them in freehand and get the general shape desired. When the square is proportionally correct, cross the center with two diagonal lines and cross these with a vertical line through the intersection of the diagonal lines. Draw a horizontal line through the center to determine the perspective center. Use the vanishing point to have the direction of the receding lines correct.

Exercises (059):

1. Using your own paper:
   a. Draw a circle (in one-point perspective) using the freehand method.
   b. Construct a circle (in one-point perspective) using the T-square and triangle (instrument method).

060. Name the three major things to remember in perspective drawing.

Compound Form. Most objects consist of compound forms that can be reduced to a basic form—as you've just seen. You can solve most of your perspective problems if you understand the cube and its relationship to perspective. The three most important things to remember are: the horizon, the station point, and the vanishing points. These are the only elements that affect the appearance of your drawings. If these elements are poorly selected but definitely established, your drawing is correct although it may be unattractive.

Remember, keep the vanishing points as far apart as possible; this gives the final picture a more pleasant appearance. Also keep all vertical lines truely vertical, except for special effects. If special effects are necessary, a third vanishing point may be needed.

Drawing a cube or a rectangle in perspective is a simple operation if you understand measurement. A rectangle in perspective can be thought of as two cubes placed end to end. If you can draw a cube and measure it, you can divide it into halves, thirds, or any number of divisions found in compound form. Compound forms need not be complex if they are thought of as cube-upon-cube in perspective.

Exercises (060):

1. What are the three most important things to remember in perspective drawing?

061. List the first two steps in drawing a plan and elevation view, and specify why a given line is most important.

Making a Plan and Elevation View. Plan and elevation views can become very complex; compound forms are to be expected. When making such a plan and elevation view in perspective, the first step is to draw a line to represent the picture plane. The plan view is arranged behind the picture plane with the nearest corner of the building just touching the picture plane (A) as shown in figure 4-116. Next, select the station point. Make the station point approximately the center of the plan view at a 30° overall angle.

Draw lines from the station point to the corners of the important parts of the building that you want to locate in your perspective drawing. Where the lines intersect the picture plane, draw vertical lines to establish accurately the width of the different parts of the structure. The most important of these lines is the line that is actually touching the picture plane (line A). It is the only line that is not foreshortened; therefore, it is the only line that can be used for vertical measurement from the elevation view.

Now you must decide on the location of the horizon line. After you have located the horizon line, draw lines (B) and (C) parallel to lines (D) and (E) in the plan view. From the points at which lines (B) and (C) intersect the picture plane, drop vertical lines to the horizon line to establish the right and left vanishing points.

The next step is to carry across vertical measurement from the elevation view to line (A) and draw construction lines from the points on line (A) to the vanishing points using the same procedure already discussed. The vertical lines dropped from the picture plane will automatically establish the width of doors, windows, walls, etc., in the perspective drawing. Remember, you can make direct vertical measurement only on line (A); it is the only true length line in the whole drawing.

Exercises (061):

1. What are the first two steps in drawing a plan and elevation view in perspective?

2. Why is line (A), figure 4-116, the most important line?

Bibliography

ECI Course

CDC 23131, Volume 1, *Fundamentals of Graphics*, Extension Course Institute, Gunter Air Force Station, Alabama 36118.

Books

Spencer, Henry C., *Basic Technical Drawing*, 7th ed. New York, New York: The MacMillan Publishing Company, 1968.

Richmond, Leonard and Littlejohns, J., *Fundamentals of Watercolor, and Fundamentals of Pastels*, 12th ed., New York, New York: The Watson Guptill Publishing Company.

Birren, Faber, Principles of Color: *A Review of Past Traditional and Modern Theories*, New York, New York: Lilton Educational Publishing Company, 1969.

Department of the Navy Publications

NAVTRA 10469-A, *Illustrator Draftsman 3 & 2*.

Answers for Exercises

CHAPTER 1

Reference:

001 – 1. a. Have a place for each piece of equipment and keep it there when not in use.
  b. Keep all instruments clean.
  c. Never expose pointed equipment to the possibility of point damage.
  d. Never use any instrument for any purpose except for which it was designed.
  e. Electrical equipment should be unplugged when not in use.
001 – 2. A systematic arrangement of tools is timesaving and efficient and decreases the possibility of accidentally dropping or pushing something off the table.

002 – 1. So that if you desire to work in a standing position, you can do so without stooping or raising your arms.
002 – 2. From the left front.
002 – 3. For tracing prints, opaquing negatives, and making color separations.
002 – 4. For jobs that may damage the surface of a drawing table.
002 – 5. It serves as a storage space for frequently used tools and materials.

CHAPTER 2

003 – 1. Air Force drawing paper dimensions are based upon the 8½" x 11" size. This dimension is used so that the larger sheets can be folded to fit into standard filing cabinets.
003 – 2. Good tracing paper must be translucent. It must also have sufficient grain to take pencil or ink, and a hard surface so the pencil will not groove it or the ink will not bleed.
003 – 3. The weight of paper is determined by the pound weight of a ream (500 sheets) of paper that measures 17" x 22".
003 – 4. The main difference between hot-pressed board and cold-pressed board is the surface finish. Hot-pressed board has a hard, slick surface; cold-pressed board has a textured surface.

004 – 1. Hard, medium, and soft.
004 – 2. Conical, wedge, and elliptical.
004 – 3. Drawing ink is finely ground carbon suspended in liquid with gum arabic added.
004 – 4. Black, dark blue, and red.

005 – 1. To draw horizontal lines.
005 – 2. Supported at both ends, it maintains parallel motion automatically, and it may be moved up or down the board with pressure at any point along its length.
005 – 3. T-square, triangle, scale, and protractor.

006 – 1. A 30° and 60° and a 45° and 45°.
006 – 2. To draw vertical or inclined lines in conjunction with the T-square.
006 – 3. Irregular curves are used to draw smooth lines through a number of predetermined points.
006 – 4. The irregular curve should match at least three consecutive points.

007 – 1. A protractor is used for setting off and measuring angles ranging from 0° to 360°.
007 – 2. Line up the baseline of the angle with the zero points of the protractor. Align the center point of the protractor directly over the apex of the angle. Measure the arc formed by the two lines.

008 – 1. Mechanical engineering, civil engineering, and architect's scales.
008 – 2. a. A mechanical engineer's scale is used to draw machine parts and small structures where the size is never less than 1/8 the original.
  b. A civil engineer's scale is used mainly for plotting and drawing maps and any work where the divisions are in tenths of inches.
  c. An architect's scale is used on any dimension where feet and inches are required.
008 – 3. "Open divided" means that the units representing feet are shown along the entire length of the scale, with only the end units subdivided into fractions representing inches.

009 – 1. It will not destroy the surface of the paper if used properly.
009 – 2. It can hold any shape, has few erasure crumbs, picks up graphite dust, and tends to clean itself when kneaded.
009 – 3. The electric eraser is difficult to use without damaging the surface of the paper.

010 – 1. Because you might bend the nibs and ruin the pen.
010 – 2. Detail.
010 – 3. Sharp points, unequal length of nibs, and flattened points.
010 – 4. It forces the nibs together and causes the thickness of the line to vary.

011 – 1. Compass and dividers.
011 – 2. A proportional divider is a type of divider that has a movable pivot point with needle points on each end. The movable pivot allows the short end to be adjusted to a ratio of the long end.
011 – 3. Three instruments—bow pen, pencil, and divider.
011 – 4. To prevent the needle from creating an unsightly hole in the paper.

012 – 1. One source of red sable bristles is the Kolinsky or red Tartar marten.
012 – 2. The character of the brush depends on where the ferrule grips the bristles.
012 – 3. The five types of brushes are: rounds, brights, flats, filberts, and lettering brushes.
012 – 4. Brushes should be stored in an open jar with their handles down and the bristles exposed to the air.

CHAPTER 3

013 – 1. Text, Gothic, and Roman.
013 – 2. Printing imposed changes in the mechanically perfected letter. It began a trend toward simplicity and ease of construction.
013 – 3. Compressed; condensed.
013 – 4. Extended.

014 – 1. Ascender, descender, serif, stem, bowl, swell, and hairline.
014 – 2. Roman letters.
014 – 3. A swell.

015 – 1. The stem and oval.
015 – 2. The stem is that straight vertical slant line that forms more than four-fifths of all letters.
015 – 3. The six basic strokes of lettering are horizontal, vertical, diagonal left, diagonal right, counterclockwise curve, and clockwise curve.
015 – 4. 67½°.
015 – 5. If the letter A does not extend slightly above the cap line, it will appear smaller than the rest of the letters.

016 – 1. Proportion stability and uniformity.
016 – 2. Uniformity.
016 – 3. By using guidelines.
016 – 4. It varies the heights of the letters.

017 – 1. Because all letters are not regular in shape.
017 – 2. There should be a full space between d and b because the stems of these letters are full height. The space between the o and b should be slightly narrower to compensate for the space above the o.
017 – 3. Four.

018 – 1. Clean; firm; opaque.
018 – 2. To hold the pencil or pen correctly and comfortably.

019 – 1. Speedball pens, technical fountain pens, text writing pens, and felt tip markers.
019 – 2. The size and shape of the nibs determine the size and style of letters you can make with any given pen.
019 – 3. A light touch is necessary to keep paper fibers from building up on the pen point.
019 – 4. Text writing pens are made of much thinner steel and produces a sharper stroke.
019 – 5. The three main parts of a technical fountain pen are the point assembly, the head assembly, and the ink reservoir.
019 – 6. The main difference between the two types of felt tip marker is that the nondisposable felt tip has a flow valve that allows the ink to reach the paper.

020 – 1. Lettering brushes have longer and more flexible bristles than painting brushes. The tips of lettering brushes are square.
020 – 2. To hold more paint and to absorb the natural shakiness of your hand.
020 – 3. Holding your brush with the label up gives you a point of reference and forces you to keep the bristles aligned the same way each time you use the brush.

021 – 1. A standard lettering set consists of a set of templates, a scriber, and a set of pens.
021 – 2. Eleven.
021 – 3. The tailpen is the back of the scriber that rides in the straight groove of the template.

022 – 1. a. Letters can be applied directly to finished artwork.
b. Can be applied to any smooth surface.
022 – 2. The letters can be applied directly to the finished artwork.
022 – 3. The letter, or part of it, will be transferred back to the lettering sheet.

023 – 1. a (ratio is 1 to 3), b (turn adjust dial), d (pull lead strip to break inner bond), e (raise only slightly), f (indicated on the typemaster), h (zero on dial).
023 – 2. e (developing process will start automatically).

024 – 1. The secretarial keyboard and display screen and the automatic developing processor.
024 – 2. It is possible to edit your copy. You may be able to justify your copy depending upon the type of system your unit uses.
024 – 3. Editing and justification is done prior to printing the film.

025 – 1. The main purpose of a waxer is to make copy, photos, or pictures adhere to art surfaces.
025 – 2. The two types of waxers are the table model, which has an automatic feed mechanism, and the hand-held model, which uses no feed mechanism.
025 – 3. The main advantage of using a waxer is the ability to move and reposition your copy without damaging your work.
025 – 4. If the wax gets too hot, it will bleed through your work. If the wax is too cold, the wax will not flow properly and will place unnecessary wear on your machine.

CHAPTER 4

026 – 1. Chord.
026 – 2. A point.
026 – 3. A principle of plane geometry.

027 – 1. A straight line is produced by a point in motion in one direction for its entire length.
027 – 2. A curved line is produced by a point in motion changing direction along its entire length.
027 – 3. A plane is a flat surface generated by a straight line moving in a direction other than its length, creating an area with length and breadth but no thickness.

028 – 1. Adjacent angles.
028 – 2. (1) c.
(2) d.
(3) f.
(4) a.
(5) g.
(6) b.

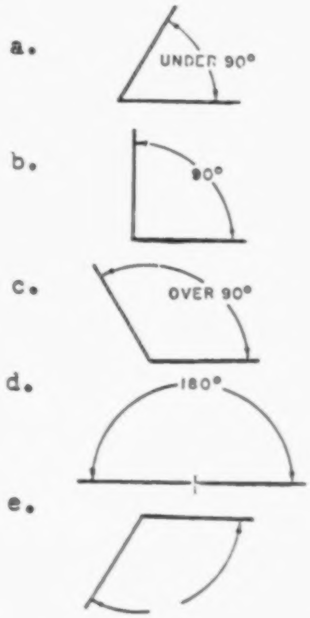


Figure A-1. Objective 028, exercise 3.

028 – 3.

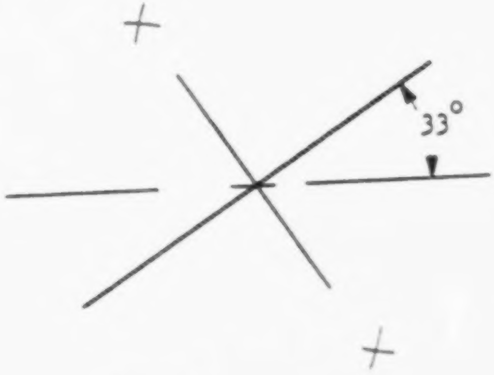


Figure A-2. Objective 029, exercise 1.

029 – 1.

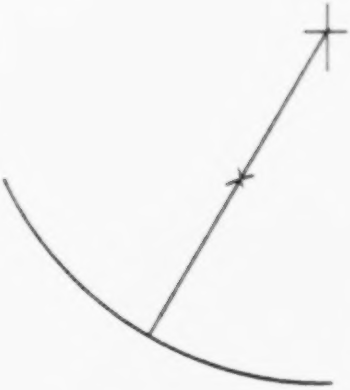


Figure A-3. Objective 029, exercise 2.

029 - 2.

030 - 1. See text figure 4-9.
030 - 2. See text figure 4-12.

031 - 1. See text figure 4-13.
031 - 2. See text figure 4-14.

032 - 1. See text figure 4-15.
032 - 2. See text figure 4-16.

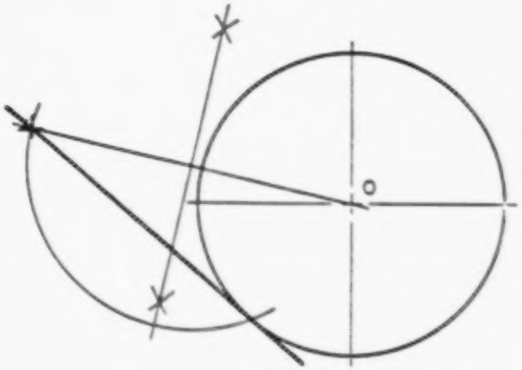


Figure A-4. Objective 033, exercise 1.

033 - 1.

034 - 1. See text figure 4-18.
034 - 2. See text figure 4-19.

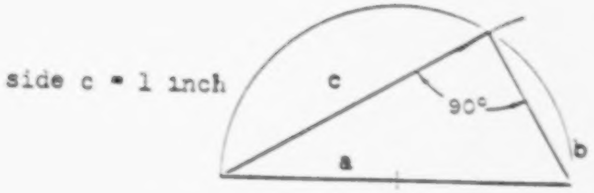


Figure A-5. Objective 035, exercise 1.

035 - 1.

035 - 2. See text figure 4-23.

036 - 1. See text figure 4-24.

037 - 1. See text figure 4-26.
037 - 2. See text figure 4-27.

038 - 1. See text figure 4-30.
038 - 2. See text figure 4-29.
038 - 3. See text figure 4-28.

039 - 1. See text figure 4-31.
039 - 2. See text figure 4-32.

040 - 1. See text figure 4-34.
040 - 2. See text figure 4-35.
040 - 3. See text figure 4-36.
040 - 4. See text figure 4-37.
040 - 5. See text figure 4-38.
040 - 6. Foci, trammel, and concentric circle methods.

041 - 1. You must know the different line types in order to completely and clearly describe an object.

042 - 1.
- a. Construction line.
- b. Short break line.
- c. Section line.
- d. Phantom line.
- e. Hidden line.
- f. Dimension line.

042 - 2. The length is 1/8", and they are 1/32" apart.

043 - 1. Parallel projections and central projections.
043 - 2. The side which shows best the contour or shape of the object.
043 - 3. When the glass box is open.

044 - 1. Six; front, top, right side, back, bottom, left side. 044 - 2 Three; front, top, right side.
044 - 3. Visible (or story) lines.

045 - 1. Half views should always be near a full view of a drawing.
045 - 2. Any view may accompany the front view, if each is equally descriptive.

046 - 1. Rounded intersections of surfaces of inside corners are known as fillets.
046 - 2. Rounded intersections of surfaces occur at outside edges and are called rounds.
046 - 3. An oblique surface is a nonparallel surface to any principal plane of projection.
046 - 4. Fillets and rounds are always shown to indicate corners of unfinished castings.

047 - 1. Vertical (or frontal plane), horizontal plane, and profile plane.
047 - 2. Third angle projection.

048 - 1. Isometric means equal measure.
048 - 2. The object is rotated 45° on its vertical axes.
048 - 3. 360°.
048 - 4. Trimetric.

048 – 5. Isometric, dimetric, trimetric.

049 – 1. All receding lines of the cabinet drawing are half the true length of the cavalier.

049 – 2. The ellipse is drawn by means of projections from the circle.

049 – 3. Line.

050 – 1. It is used to expose internal features of an object.

050 – 2. The arrows show the direction in which the cut surface is viewed through the cutting plane.

051 – 1. Glass box method and customary projection method.

051 – 2. To obtain a true size and shape view, you place a picture plane so that it is parallel to the inclined face.

052 – 1. An auxiliary view is required when the true size and shape of a portion of an object are not shown in the regular top, front, or side view.

052 – 2. Yes, the auxiliary plane is rotated until it coincides with the front plane.

052 – 3. Line; symmetry.

053 – 1. A distance on a drawing may be given either by a dimension or by a note.

053 – 2. Extension lines, dimension lines, and leader lines.
  a. Extension lines are thin, solid lines that start about 1/16" from the object and extend about 1/8" beyond the last dimension line.
  b. Dimension lines are thin, solid lines, terminated at each end by arrowheads, and indicate the direction and extent of the dimension.
  c. A leader is a thin, straight line that begins at a dimension or note and terminates in an arrowhead at the point of reference.

053 – 3. An arrowhead is three times as long as it is wide.

053 – 4. A finish mark indicates that a certain surface must be changed by machining, drilling, filing, or grinding.

054 – 1. Size dimensioning involves the dimensions of height, width, and depth.

054 – 2. Prism.

054 – 3. A right cone is a conical-shaped object with the apex perpendicular to the base. A frustum cone is a conical-shaped object with a portion of the top removed. An oblique cone is a conical-shaped object with the apex angle other than 90°.

054 – 4. Location dimensioning involves dimensions that will position each form in relation to the other.

054 – 5. Dimensioning shapes that are considered standard features are circles and arcs, curves, angles, chamfers, tapers, holes, countersinks, counterbores, spotfaces, and rounded ends.

055 – 1. Clarity.

055 – 2. Dimensions should be placed between views whenever possible, outside the views if there is no room between views, or on the views if all else fails.

055 – 3.
  a. Complete the shape description.
  b. Place the extension lines and extend the center line where necessary. Plan for the location of both size and location dimensions. Study the placement of each dimension and make alterations, if desirable or necessary.
  c. Add the dimension lines.
  d. Draw arrowheads and leaders for notes.
  e. Add dimension values.
  f. Letter notes.

055 – 4. Roughness is expressed as the arithmetic average deviation from the mean line of the surface in profile.

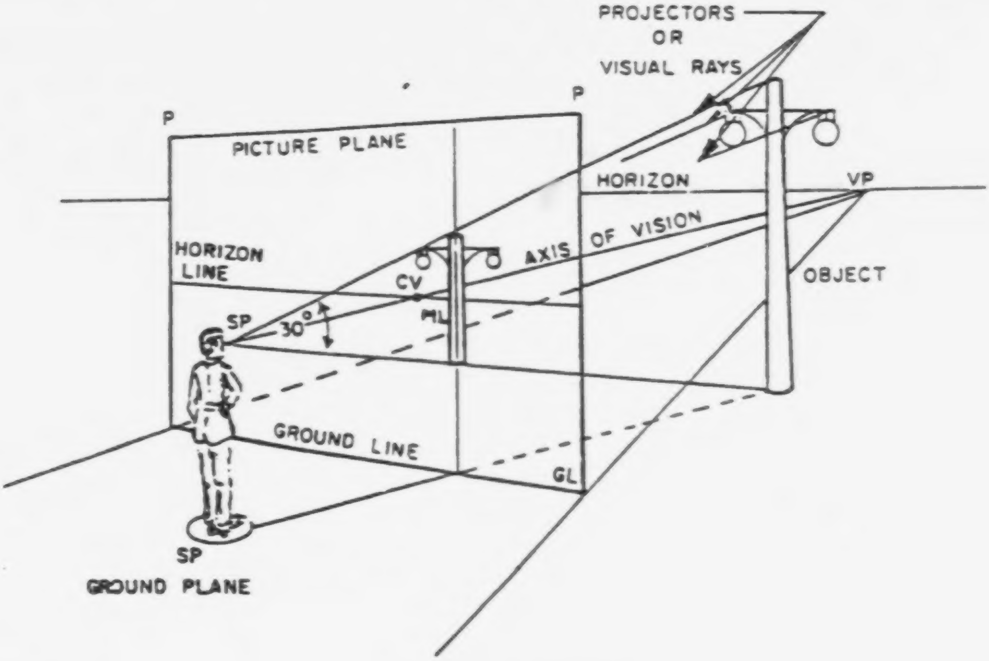


Figure A–6. Objective 056, exercise 1.

056 – 1.

056 – 2. Definitions:
  a. Horizon is a visible or invisible line that represents the actual horizon and eye level of the observer.
  b. Vanishing point (VP) is the point on the horizon where all lines representing parallel horizontal edges converge.
  c. Ground line represents the intersection of the ground plane and the picture plane.
  d. Picture plane represents the rectangular outline (real or imaginary).

e. Station point is the point through which all converging light rays go; position of observer's eyes in relation to object.
f. Visual rays are converging light rays.
g. Center (line) of vision (CV) (axis of vision) is the observer's line of sight. It is the point at which this line intersects the picture plane.
h. Object plane is any vertical surface of the object.
i. Horizon plane is an invisible plane passing through the station point and Earth's horizon.
j. Measuring line (ML) is the part of the object that touches the picture plane.

056 – 3. Due to the fact that the SP is in relation to the object, if the point shifts, the perspective also shifts accordingly.

056 – 4. By changing (augmenting or decreasing) the perspective; if the picture plane moves closer to the object, the perspective becomes larger. The converse is true, as well.

057 – 1. Three types of perspective are:

a. One-point (parallel) exists when two dimensions are parallel to an imaginary plane of reference (picture plane).
b. Two-point (angular): Object is considered as sitting at an angle to the picture plane. In the perspective drawing of such an object, there are two sets of horizontal edges converging toward two different vanishing points on the horizon.
c. Three-point (oblique): Occurs when none of the object's surfaces are parallel to the picture plane. Three-point perspective is usually needed when the station point is close to the object and the picture plane is at an angle to the horizon line. The third vanishing point is above the horizon when the horizon is low, and below the horizon when the horizon is high.

057 – 2. View A is parallel (one-point) perspective.
View B is angular (two-point) perspective.
View C is oblique (three-point) perspective.

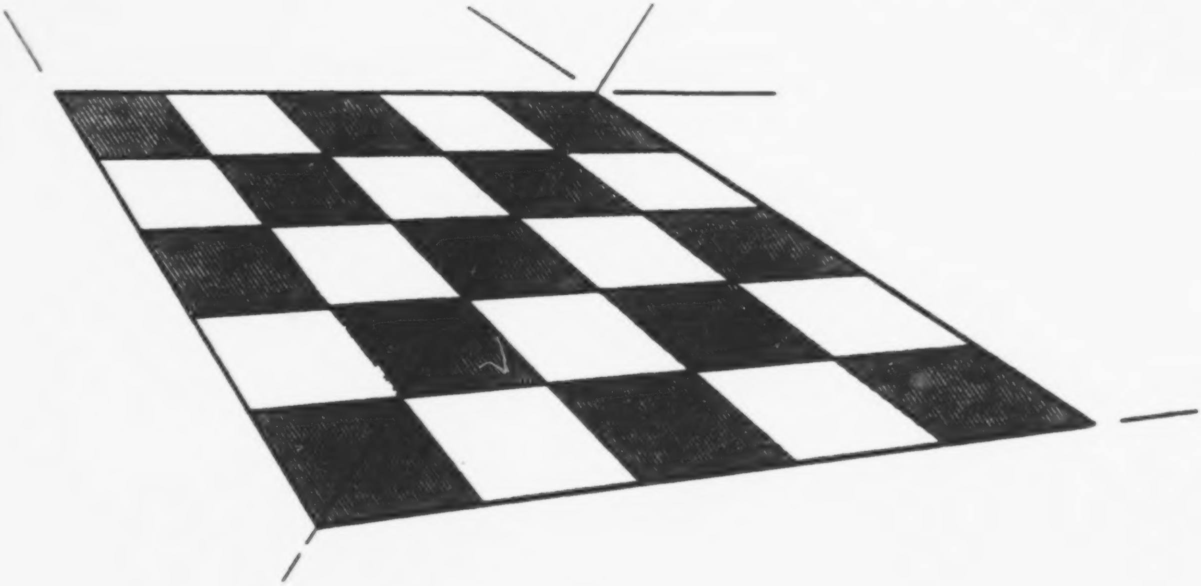


Figure A–7. Objective 058, exercise 1.

058 – 1.

058 – 2. To establish the needed station point and vanishing point(s).

b.

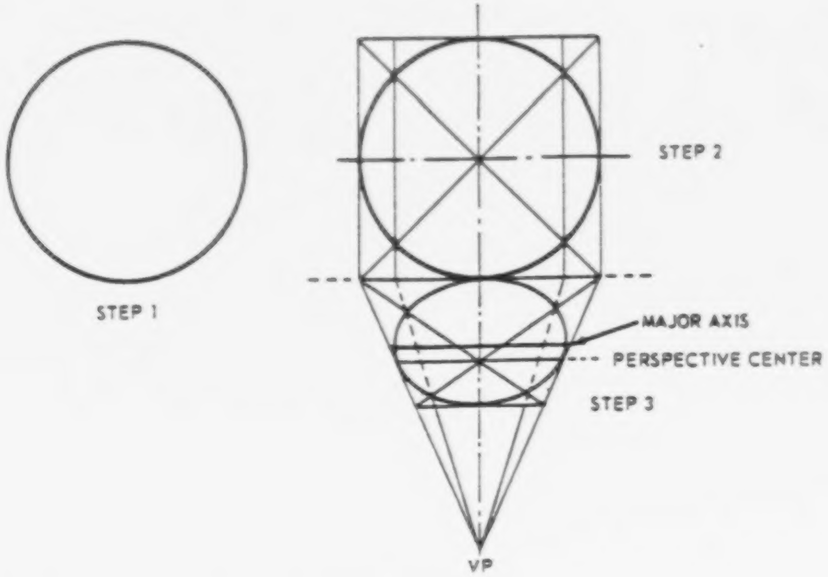


Figure A-8. Objective 059, exercise 1.

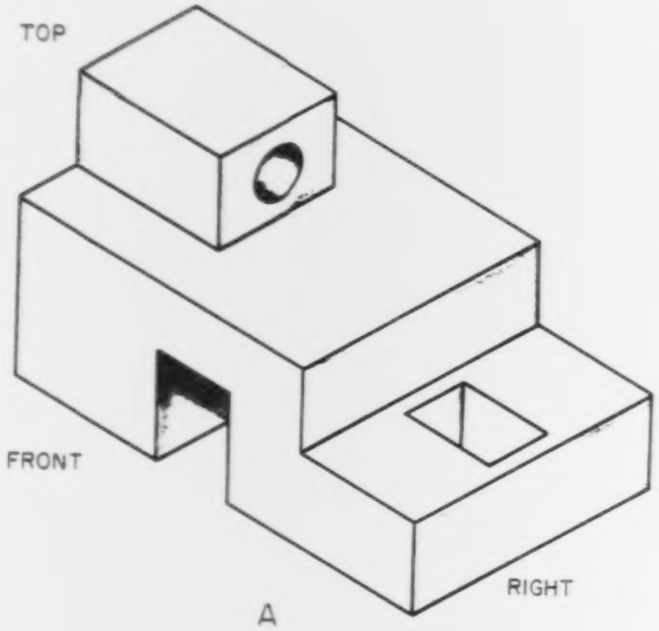
059 – 1.

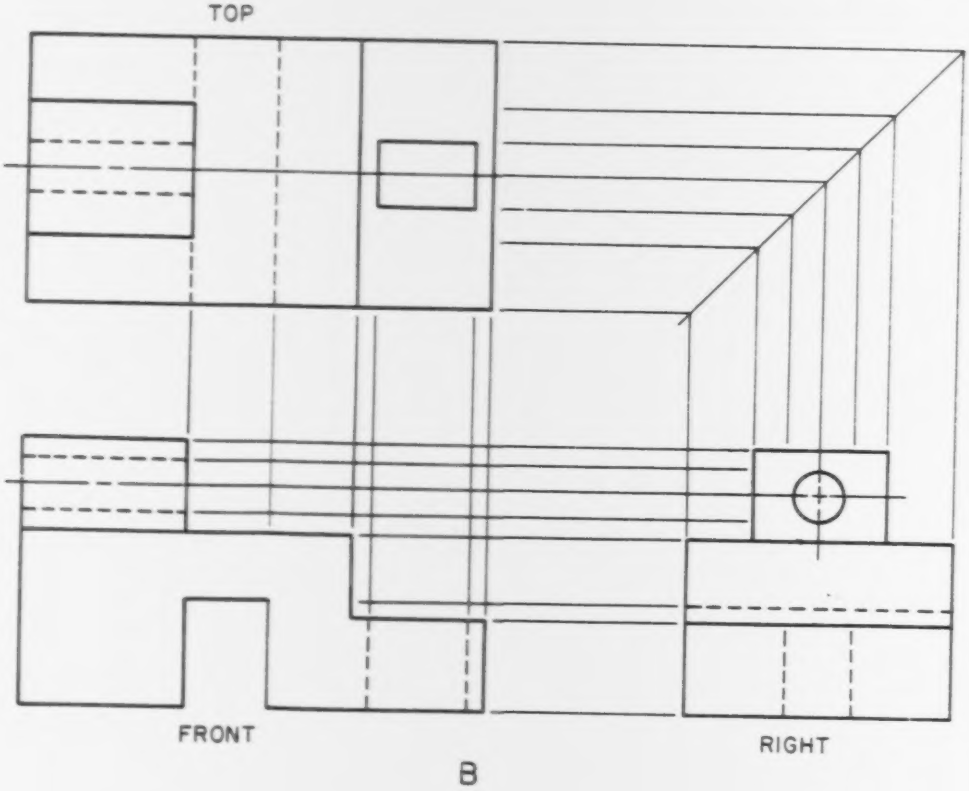
060 – 1. The horizon, the station point, and the vanishing point(s).

061 – 1. a. Step one is to draw a line to represent the picture plane.

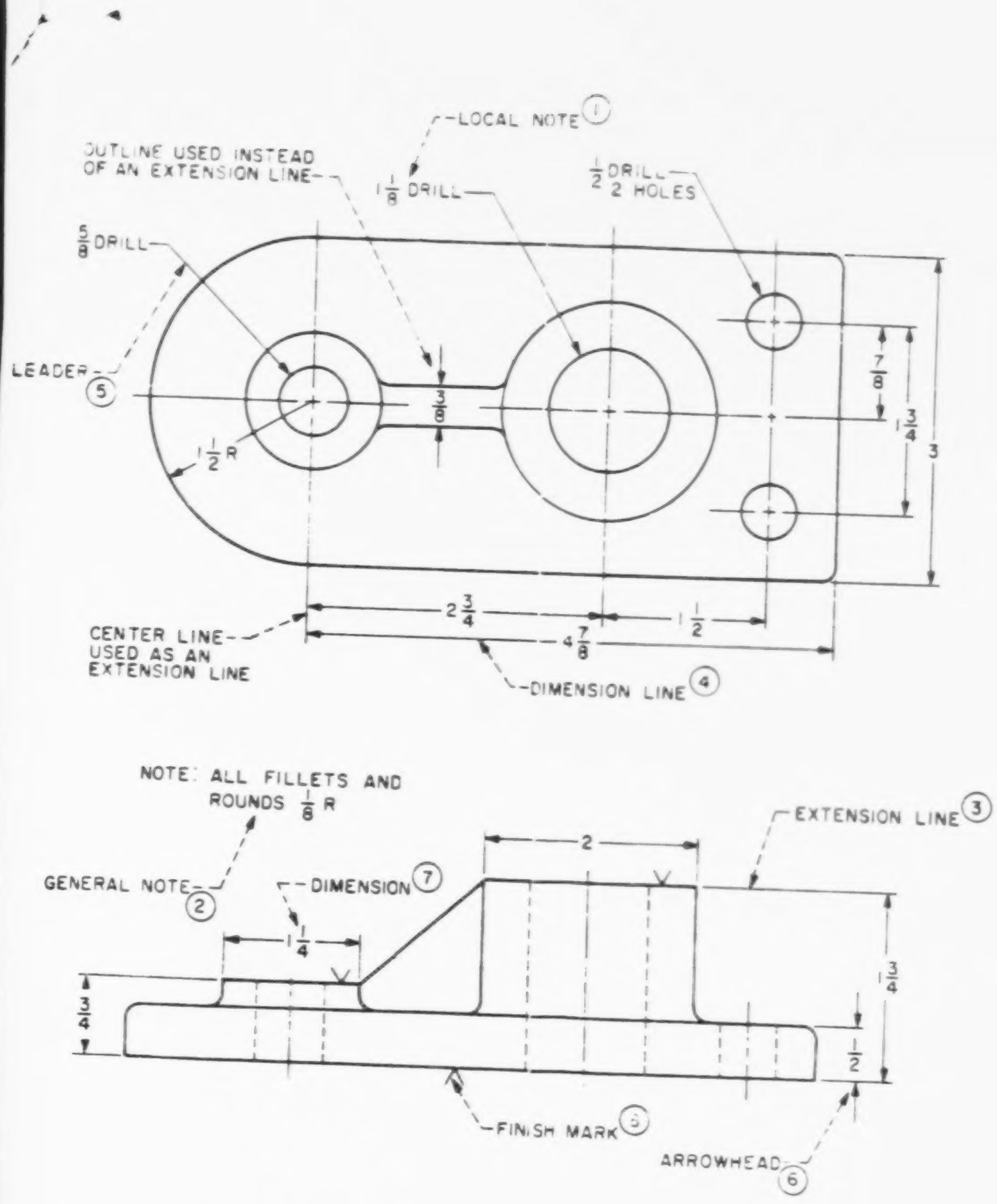
b. Step two is to select the station point (approximately the center of the plan view at a 30° overall angle).

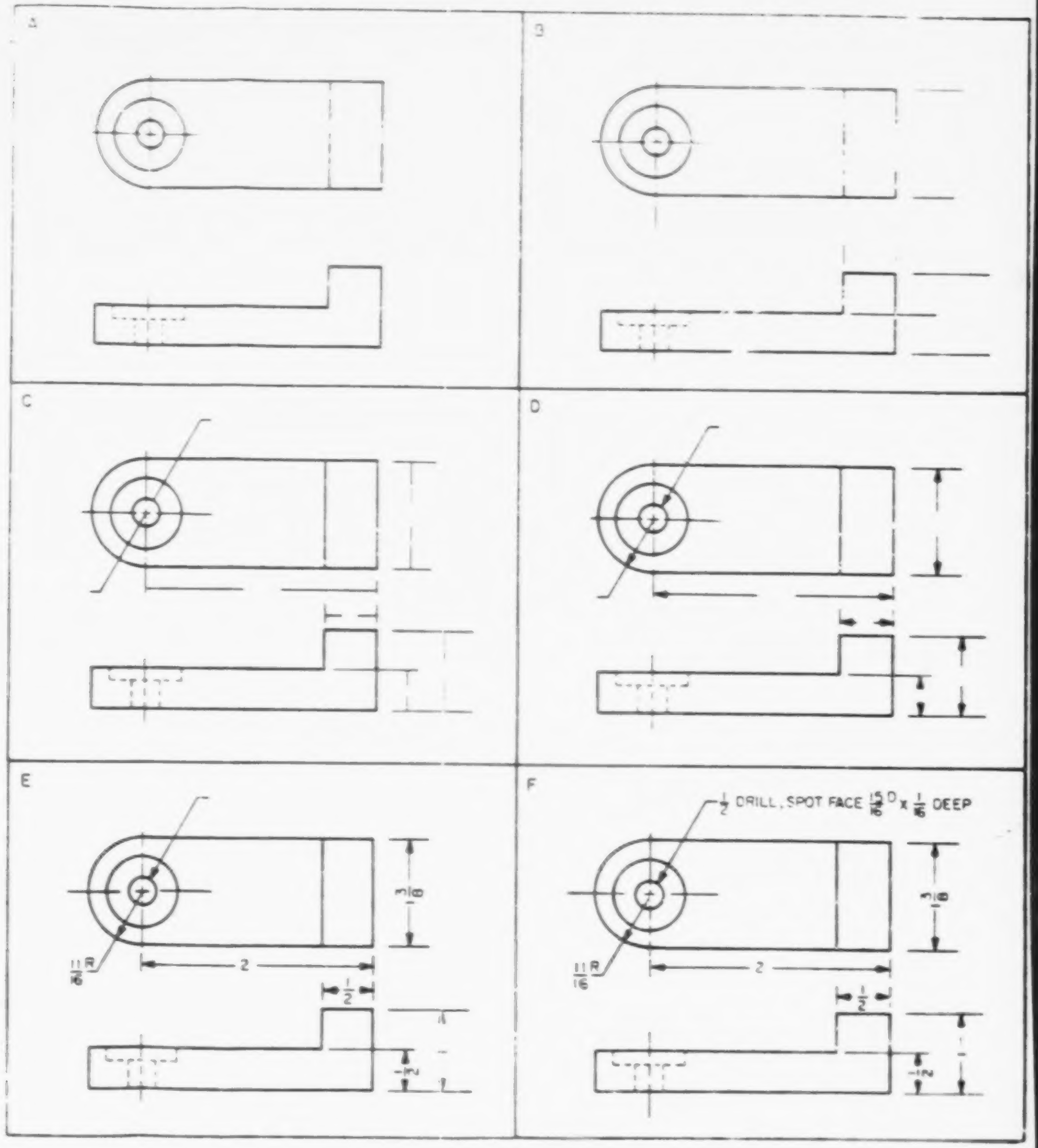
061 – 2. Line (A) actually touches the picture plane; thus, it is not foreshortened (to be discussed further in the next increment). In fact, line (A) is important because it can be used for measuring.


TOP
FRONT
RIGHT
A


TOP
FRONT
RIGHT
B

Foldout 1. Multiview projection.


LOCAL NOTE ①
OUTLINE USED INSTEAD OF AN EXTENSION LINE
1 1/8 DRILL
1/2 DRILL 2 HOLES
5/8 DRILL
LEADER ⑤
3/8
7/8
1 3/4
3
1 1/2 R
2 3/4
1 1/2
4 7/8
CENTER LINE USED AS AN EXTENSION LINE
DIMENSION LINE ④
NOTE: ALL FILLETS AND ROUNDS 1/8 R
GENERAL NOTE ②
DIMENSION ⑦
EXTENSION LINE ③
2
1 1/4
3/4
1 3/4
1/2
FINISH MARK ⑧
ARROWHEAD ⑥


A
B
C
D
E
F
1/2 DRILL, SPOT FACE 15/16 D x 1/16 DEEP
11/16 R
2
5/8
1/2
1/2

Foldout 2. Order of dimensioning.

STOP- 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

23151 01 23

BASIC EQUIPMENT, MATERIALS, TOOLS LETTERING, AND DRAFTING

Carefully read the following:
DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover *your* answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor. If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the *best* answer to each question.

1. (001) Which of the following choices states an incorrect rule for proper equipment care?
   - a. Use special solvents for all equipment cleaning.
   - b. Never use any instrument for any purpose other than that for which it was designed.
   - c. Keep all instruments clean.
   - d. Never expose any pointed equipment to the possibility of point damage.

2. (002) Why are most drawing boards and tables cleated with a metal edge?
   - a. To prevent work from slipping off the board.
   - b. To help protect the drawing surface.
   - c. To prevent warping and act as a straight working base for a T-square.
   - d. To give the board stability and protection for the edges.

3. (002) A work table should be covered with what kind of material and why?
   - a. With acetate to give it a smooth working surface.
   - b. With plexiglass to protect the wood.
   - c. With nothing, it is perfectly fine as is.
   - d. With a sheet of scrap illustration board to prevent cutting through with a blade.

4. (003) Drawing paper should have all the following qualities *except*
   - a. a smooth surface after erasure.
   - b. a slick surface.
   - c. a hard surface.
   - d. grain.

5. (004) Which grades of pencil lead are classified as soft?
   - a. 2B to 6B.
   - b. B to 3H.
   - c. 4H to 9H.
   - d. HB to 4B.

6. (004) Which of the following grades of pencil is *most* suitable for tonal sketches?
   - a. 4H.
   - b. 6B.
   - c. HB.
   - d. F.

7. (004) Which color inks will best reproduce photographically?
   - a. Black, green, or violet.
   - b. Green, light blue, or red.
   - c. Black, dark blue, or red.
   - d. Red, blue, or yellow.

8. (005) What is one advantage that a parallel straightedge have over a T-square?
   - a. It is supported at both ends.
   - b. It is more exact.
   - c. It is easier to use.
   - d. There is no advantage.

9. (005) Which of the following illustrating tools can be replaced by the drafting machine?
   - a. T-square, compass, triangle, and scale.
   - b. T-square, triangle, scale, and protractor.
   - c. Compass, triangle, scale, and protractor.
   - d. T-square, scale, protractor, and compass.

10. (006) When you use an irregular curve to draw a smooth line through predetermined points, the curve should match the line at a minimum of how many consecutive points?

a. Three.
b. Five.
c. Seven.
d. Nine.

11. (007) The function of a protractor is to

a. draw parallel lines.
b. measure line length.
c. draw angles.
d. measure angles.

12. (008) What is the smallest division on a mechanical engineer's scale

a. 1/8 inch.
b. 1/4 inch.
c. 1/2 inch.
d. 1 inch.

13. (008) Which of the following scales is divided into proportional divisions representing feet and inches?

a. Mechanical engineer's scale.
b. Civil engineer's scale.
c. Architect's scale.
d. Ruler.

14. (009) The eraser that leaves the least amount of debris is

a. ruby eraser.
b. pencil eraser.
c. art gum eraser.
d. kneaded eraser.

15. (010) The primary purpose of a ruling pen is to make

a. straight lines of uniform thickness.
b. straight lines of varying thickness.
c. curved lines of varying thickness.
d. curved lines of uniform thickness.

16. (011) The lead for a compass should be

a. one grade harder than used in pencil work.
b. one grade softer than used in pencil work.
c. two grades harder than used in pencil work.
d. the same grade as used in pencil work.

17. (012) The hair of the red sable brush is noted for its

a. springiness and durability.
b. softness and elasticity.
c. precise shape.
d. bristle color.

18. (013) Which of the following lettering styles is used for most books, magazines, and newspapers?

a. Italic.
b. Gothic.
c. Text.
d. Roman.

19. (014) The stem of a lowercase letter that extends above the body of the letter is called the

a. serif.
b. ascender.
c. swell.
d. descender.

20. (014) Serifs are characteristic of what type of letter?

a. Gothic.
b. Italic.
c. Roman.
d. Text.

21. (015) Refer to figure 3-2. What are the six basic strokes used in lettering?

- a. Vertical, horizontal, slanted, oval, curve, and reverse curve.
- b. Vertical, horizontal, diagonal, slanted, round, and oval.
- c. Vertical, horizontal, diagonal, oval, round, and straight.
- d. Vertical, horizontal, diagonal right, diagonal left, clockwise curve, and counterclockwise curve.

22. (016) The easiest way to ensure good height and inclination in lettering is to use

- a. spacers.
- b. guidelines.
- c. lobars.
- d. modems.

23. (017) To obtain good spacing you might have to alter which of the following combinations of letters?

- a. UM.
- b. AY.
- c. LA.
- d. AU.

24. (018) When you are lettering, it is *not* necessary that the penciling be

- a. shaded.
- b. clean.
- c. firm.
- d. opaque.

25. (019) Which type of speedball pen can be used to make Roman style lettering?

- a. A.
- b. B.
- c. C.
- d. D.

26. (020) Why do lettering brushes have long bristles?

- a. To allow for a greater amount of flexibility and versatility.
- b. To hold enough paint to complete an even stroke.
- c. To wear longer.
- d. To create larger and more complex letters.

27. (021) How many size pens are there in a mechanical lettering set?

- a. 8.
- b. 9.
- c. 11.
- d. 12.

28. (022) If a strip of prepared lettering is placed on a curved line you should cut

- a. each letter and place it individually along the curve.
- b. between the letters except in the center of the strip.
- c. notches along the top and bottom of the strip.
- d. between the letters leaving the bottom of the strip uncut.

29. (023) To insert paper into the photo composing machine, raise the front cover and the lighthouse then

- a. insert paper into paper well.
- b. release the guide control lever.
- c. pull out the paper feed clutch knob.
- d. center the drive feed locating pin.

30. (024) How many characters are there in a type style used in a computer generated photo typesetter?

- a. 96.
- b. 102.
- c. 120.
- d. 144.

31. (025) Waxers are used to apply a thin coat of wax to the

a. back side of your copy.
b. diazo film.
c. frisket paper.
d. illustration board.

32. (026) A plane curve, the path of a point the sum of whose distances from the foci (two fixed points) is constant; a conic section, the closed intersection of a plane with right circular cone perpendicular to its side, describes

a. a helix.
b. an ellipse.
c. eccentric circles.
d. concentric circles.

33. (027) A line that changes in direction along its entire length is a

a. curved line.
b. broken line.
c. straight line.
d. helix.

34. (028) When two straight lines meet at a point, which of the following figures is formed?

a. A rhombus.
b. An angle.
c. A prism.
d. A triangle.

35. (029) Given an arc or a line, the first step in the bisecting process is to

a. set the compass for any radius greater than one-half of the given line or arc.
b. set the compass for a radius equal to one-half of given line or arc.
c. set the compass for any radius less than half of the given line or arc.
d. set the compass for a radius equal to the given line or arc.

36. (030) Curved parallel lines can only be drawn by

a. trial and error.
b. the hypotenuse method.
c. geometric construction.
d. the pin and string method.

37. (031) When dividing space into equal parts it is necessary to use a

a. compass and a scale.
b. scale and a triangle.
c. triangle and a compass.
d. scale and dividers.

38. (032) Which one of the following statements is *correct* when constructing a line tangent to a circle at a point?

a. A tangent to a circle is perpendicular to a radius at the point of tangency.
b. A tangent to a circle is never perpendicular to a radius at the point of tangency.
c. A line tangent to a circle is only perpendicular to a radius when using a 45 degree triangle.
d. A line tangent to a circle is sometimes (but not always) perpendicular to a radius at the point of tangency.

39. (033) The steps for constructing a line tangent to a circle and from a point outside a circle are similar, however, from a point outside a circle you have to

a. strike two arcs.
b. bisect an arc.
c. strike four arcs.
d. bisect a line.

40. (034) When drawing an arc tangent to a straight lien and an arc or a circle, the first step is to

a. take the given radii R1 and R2; strike an arc from the center of the circle or arc.
b. draw a line parallel to the given line.
c. draw a line parallel to the given line halfway between the circle and the given line.
d. adjust the compass to a distance equal to twice the distance of R1.

41. (035) Which type of triangle can be constructed by drawing a semi-circle?

a. Isosceles.
b. Acute.
c. Equilateral.
d. Right.

42. (036) The simplest way to construct a square with the distance across the corners given is to use

a. dividers and compass.
b. T-square and compass.
c. T-square and triangle.
d. compass and triangle.

43. (037) When constructing a regular pentagon inscribed within a given circle the first step is to

a. measure the radius of the circle.
b. draw any diameter of the circle.
c. strike an arc with a given circle.
d. extend radius line outside the circle.

44. (038) When you are constructing a hexagon that is *not* inscribed in or circumscribed about a circle, you must use the across corner method

a. with a compass.
b. with a 30°-60° triangle.
c. using a T-square only.
d. using a 45° triangle.

45. (039) Refer to figure 4-31. The two methods for constructing a regular octagon are described as using the widths across the flats and the width across the corners. What is meant by flats?

a. The distances measured from one flat surface to another parallel flat surface.
b. Any surface of an octagon.
c. The distances measured from any corner.
d. The distances measured from the center.

46. (040) When you are drawing an ellipse using the foci method, the focus points are located by using a compass radius equal to

a. the major axis minus one-half the minor axis.
b. the major axis minus the minor axis.
c. one-half the major axis.
d. one-half the minor axis.

47. (041) The language of lines was developed to

a. conform with SAE standards.
b. transfer math logic to engineering logic.
c. itemize all lines used in geometric drawing.
d. avoid confusion and misinterpretation.

48. (042) The heaviest line used in a geometric drawing is a

a. section line.
b. center line.
c. border line.
d. visible line.

49. (042) A phantom line is used in geometric drawings to show

a. where an imaginary cut in the object is made.
b. change positions of a moveable object.
c. a cross section area of your drawings.
d. necessary details of the object hidden from view.

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50. (043) Any projection made by lines of sight which are perpendicular to the image plane is

a. a central projection.
b. an orthographic projection.
c. an oblique projection.
d. a trimetric projection.

51. (044) The basic purpose of all multiview projections is to show

a. the approximate size of the object being represented.
b. the approximate size and shape of the object being represented.
c. all six views of the object being represented.
d. the true size and shape of the object being represented.

52. (045) A half view of a drawing should always be the portion

a. showing the most detail of the drawing.
b. nearest to the other half of the drawing.
c. nearest to the full view of the drawing.
d. nearest to the top view of the drawing.

53. (046) When the surface is at an acute or obtuse angle to all parallel or principle planes of projection, it is said to be

a. a right angle.
b. an oblique surface.
c. an auxiliary surface.
d. an auxiliary angle.

54. (047) When the right-side view is projected with the object between the observer and the profile plane, the type of projection is

a. first angle.
b. oblique.
c. third angle.
d. central.

55. (048) In which of the following types of projection would each angle formed by the axonometric axes equal 120°?

a. Perspective projection.
b. Trimetric projection.
c. Isometric projection.
d. Dimetric projection.

56. (049) In a cabinet drawing, which dimensions are one half those of a cavalier drawing?

a. All dimensions.
b. Only the vertical lines.
c. Only the horizontal lines.
d. Only the receding lines.

57. (050) What is the effect of passing a cutting plane through an object?

a. Solid outlines are eliminated.
b. The portion of the object behind the plane is removed.
c. Internal features can be viewed through the plane.
d. The need for an orthographic view is eliminated.

58. (051) Which statement about a primary auxiliary view is *true*?

a. It is not used as a partial view.
b. It is used to show how the entire object appears.
c. It is projected from a principle view in which an inclined surface appears as a line.
d. It is projected from a principle view in which an inclined surface appears foreshortened.

59. (052) The most common used view in geometric drawing is

a. primary auxiliary.
b. partial auxiliary.
c. complete auxiliary.
d. single auxiliary.

60. (053) The length of arrowhead with curved sides is how many times the width?

a. 1.
b. 2.
c. 3.
d. 4.

61. (054) Since every solid object has three dimensions (height, width, and depth), dimensioning these distances is called

a. location dimensions.
b. size dimensions.
c. standard dimensions.
d. regular dimensions.

62. (055) When dimensioning basic geometric forms, dimensions should be

a. placed between views whenever possible.
b. placed on the views whenever possible.
c. duplicated whenever possible.
d. placed to the right of all views.

63. (056) What is the point on the horizon where all horizontal parallel receding lines converge?

a. Vanishing point.
b. Station point.
c. Ground line.
d. Picture plane.

64. (056) The point through which all converging light rays pass is called the

a. picture plane.
b. vanishing point.
c. station point.
d. axis of vision.

65. (057) When does parallel or one-point perspective occur?

a. When the height and width are oblique to the picture plane.
b. When the height and width are parallel to the picture plane.
c. When the horizon line is above the object.
d. When the horizon line is below the object.

66. (057) What is another name for angular perspective?

a. Four-point perspective.
b. Three-point perspective.
c. Two-point perspective.
d. One-point perspective.

67. (058) What should be established before any measurements are made?

a. The horizon line.
b. The size of the object.
c. The needed vanishing points and the horizon.
d. The needed vanishing points and station point.

68. (059) When drawing circles in perspective it is often best to

a. use the four center layout method.
b. use an oblique circle template.
c. draw a cube in perpendicular.
d. rough them in freehand first.

69. (060) Why is it necessary to keep the vanishing points as far away as possible?

a. It is easier to draw.
b. It moves the station point closer to the object.
c. It creates a more pleasing appearance.
d. It shifts the horizon to the proper elevation.

70. (061) The station point should be placed

a. at the center of the plane view at a 30° angle.
b. to the left of center of the plane view at a 30° angle.
c. to the right of center of the plane view at a 30° angle.
d. at the center of the plane view at a 45° angle.

END OF EXERCISE

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Volume 2

Basic Drawing

Extension Course Institute
Air University

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN THIS VOLUME, the study of basic form, layout and composition, human form, cartoons and caricatures, ~~and landscapes~~, all deal with the drawing of form and how to construct a basic layout.

Most of the drawings in this volume are ~~plate on~~ concerned with basic construction. Foldouts 1 through 12 are oversized figures and therefore are printed and bound as a separate inclosure to this volume. Whenever you are referred to one of these foldouts, please turn to the separate inclosure and locate it.

This CDC also contains Behavioral Objectives designed to help you understand what the subjects are all about. Studying the text and achieving the objectives will give you the fundamental knowledge you need to perform as a graphic specialist. Guided by the Behavioral Objectives, answer the exercises for each chapter. Then, refer to the answer section in the back of the volume and check your answers.

Code numbers appearing on figures are for preparing agency identification only.

This volume is valued at 12 hours (4 points).

Material in this volume is technically accurate, adequate, and current as of December 1982.

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CHAPTER 1

Fundamentals of Drawing

FORM IS THE SHAPE and structure of anything and everything that exists in this world. When we talk about form, we generally think of a three-dimensional shape—with height, width, and depth. When starting an illustration, all form should be thought of as solid and basic.

1-1. Form

Form exists because all things have mass; they occupy space; and they have an appearance that you can "feel" without touching.

Every object that exists anywhere—from aardvarks to zebras—has form. Any picture you draw must be drawn so that the illustration is a convincing illusion of real form. For this reason, we teach the basic principle of all drawn form as being solid form. When you understand this principle and that everything has a top, bottom, and sides, a small step in understanding all basic form will have been accomplished. Most drawings that lack these fundamentals seem flat and lifeless.

Starting with this section, we are going to show you and teach you the principles of drawing objects so that they look solid—as if they really existed. You will be shown how to make each object look near or far, and to accentuate its form by the proper use of light and shade. When you understand these principles of form drawing and are able to apply them to any illustration, the art world is your oyster.

200. List the four basic forms.

Four Basic Forms. The four basic forms are the sphere, the cylinder, the cone, and the cube, as shown in figure 1-1. Gifted artists perceived long ago that all things can be reduced to one of the four basic forms—or modifications or combinations of one or more of these basic shapes. They found that all objects, no matter how complicated or sophisticated they may appear at first glance, are basically made up of the sphere, the cone, the cylinder, the cube, or some combination of these shapes. When you lean to draw these forms and combine them where necessary, you can draw anything you see or can imagine.

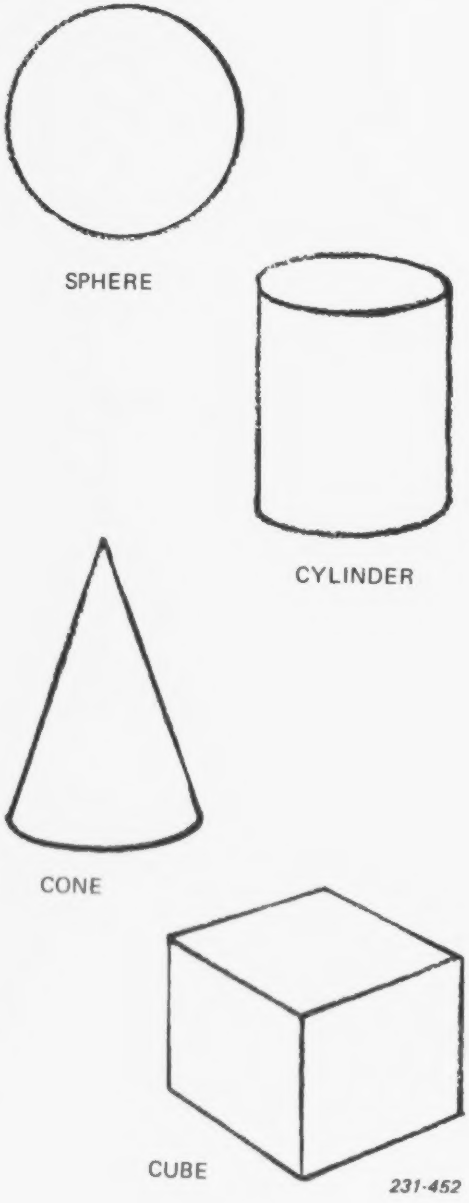

Figure 1-1. Basic Form.

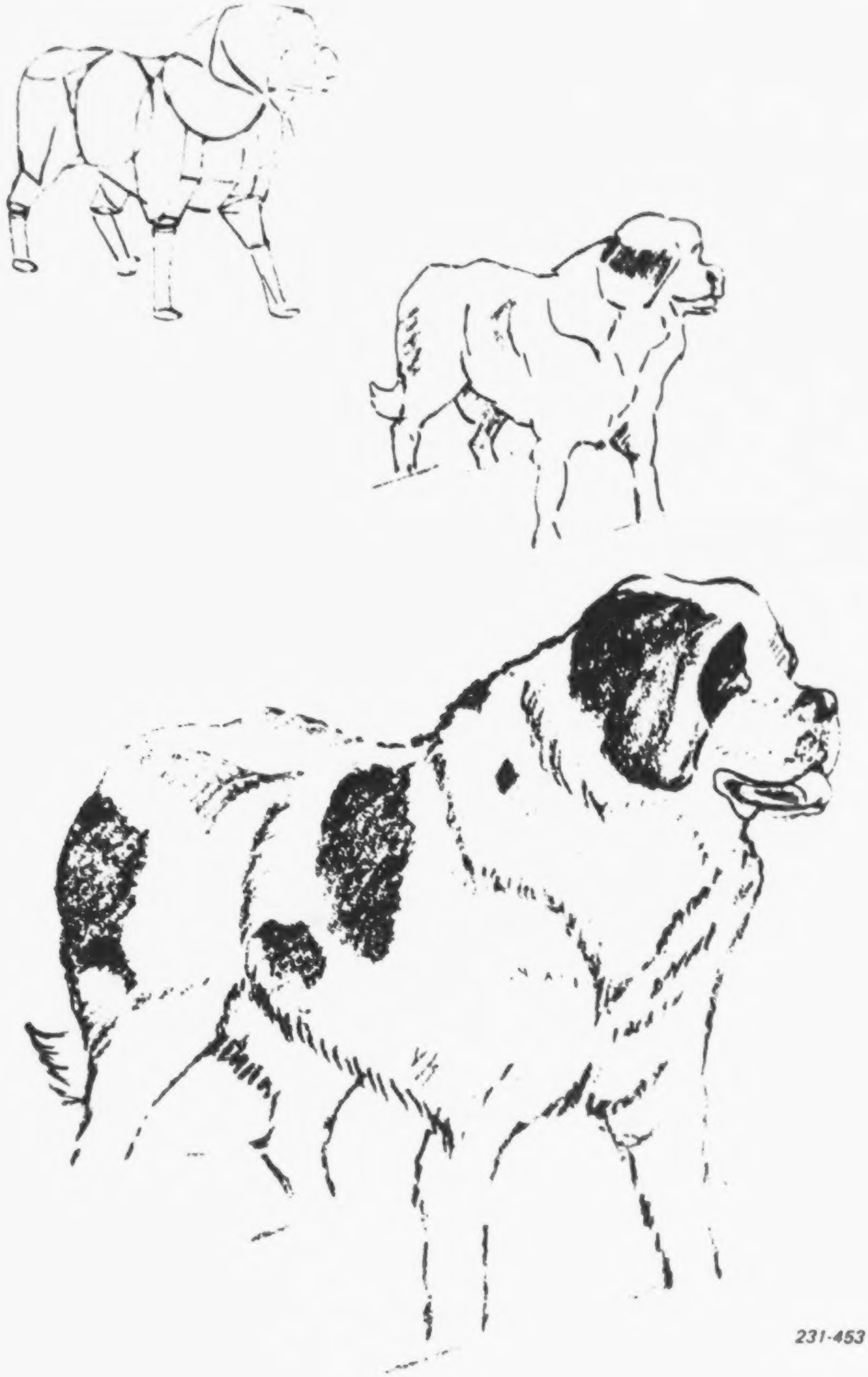

Figure 1-2. Drawing through.

The principle of drawing form is the backbone or foundation of your training. You will be reminded of form at every opportunity. Naturally, you are not expected to master the drawing of basic form in one or two sessions, but as time goes on and with a minimum amount of practice, you are expected to get the idea. When you first realize how to see basic forms in everything you come in contact with daily, you then will realize how profoundly form influences your thinking and improves your drawing.

When the sense of using form as a base, and the *feel* of solid form becomes second nature to you, you will be thinking like an artist. All the things you draw will be convincing and you will receive great satisfaction in your accomplishments. See foldout 1 (printed as a separate supplement to this volume.)

Exercises (200):

1. What are the four basic forms?

2. What is the foundation of all art?

1-2. Form in Depth

In showing you how to draw form, it would help if you also viewed the object in your picture with a sense of reality. All pictures should have the feeling of being three-dimensional, particularly the dimension of depth.

201. Define depth and specify what is meant by "drawing through."

The Dimension of Depth. Depth is the dimension that creates the illusion of a three-dimensional object drawn at a two-dimensional surface. Since your drawing paper is a flat two-dimensional surface, the one dimension that you strive for is depth.

To draw depth, you must sense the mass and substance of the object being drawn. To draw a convincing illusion of any object, the basic form of the object must be seen to extend back into the space you have created for your picture. All sides of the object must be drawn, not just the flat outline—this is called *drawing through.*

Drawing through is the one principle that makes your picture look real and convincing even if the actual drawing is not the greatest. In figure 1-2 are examples of what is meant by the "draw through" method. Let's assume, for example, that you wanted to draw a book. From where you are sitting, only the top and two sides can be seen. There are two other sides and a bottom to this book. The draw-through method, all sides, top, and bottom, should be sketched in just as though you could see all the other parts.

No matter what you draw, make it a rule to first sketch in the basic form as if you could see through the object and see all sides. If you disregard this rule, objects may appear to be lopsided, or seem to occupy the same space in your drawing. Beneath the shading and texture of all good illustrations lies a form—a form in depth. Beginners tend to concentrate on the obvious when drawing. Everyone wants to be another Michelangelo and start drawing pretty pictures right now. In other words, they respond too quickly to the surface appearances. All shading and texture seen in a drawing are part of the final stages. A great deal of preparation must be worked out with the basic forms to create that feeling of depth. Then and only then can the final stages be drawn so that you get the feeling of being.

(Exercises (201):

1. What is depth?

2. What do we mean by drawing through?

202. Specify the effect of light and shade in combination with basic forms.

Light and Shade. After you have drawn the form using the draw-through method, the basic drawing must be able to stand by itself as a sound form structure. Light and shade are essential to emphasize form in the drawing. They will help to make a good basic drawing more convincing, but will not save a poor one.

Begin now to train your eyes to see the basic form in all things. Remember, too, that most objects are combinations of two or more basic forms. In manmade structures the basic forms are easy to see, but nature can complicate matters somewhat with forms like clouds, mountains, animals, and man. So don't get bogged down with light and shade before you have the basic form. Light and shade can help you once the basic form has been drawn.

Complex form. Complex form can be a problem in that you must create the illusion of space with combinations of form. Furthermore, this sense of space must extend around these objects and beyond them in every direction. Space, forms, and perspective contribute a strong dramatic impact to every picture drawn.

Work out the size, placement, and proportion of the big forms in your picture; then proceed to carefully draw in the details. See foldout 2 (printed as a separate supplement to this volume.)

Exercise (202):

1. Why do you use light and shade in a drawing?

1-3. Techniques of Line and Tone Media

One of the problems confronting you is that of deciding which medium and technique to use when producing a particular illustration. The term "media" refers to the material with which you work, such as pencil, pen and ink, tempera, etc. The term "technique" refers to the method of handling the materials to achieve the desired effect. One would not spend a great deal of time and effort on an illustration that will only be used once. The technique on such an illustration must be adequate to get the job done. As you develop the skill of handling basic techniques, you will develop a style of expression unique to you alone.

The discussion will be on the techniques used in line and tone media. Line and tone are the two main classifications of such media.

Line Media. Line media include illustrations that are composed entirely of black and white areas. This means that there are no intermediate values of gray. For example, this page may be considered as being created in the line media since only values of black and white are used to produce it. It is composed entirely of black letter shapes against the white background of the page. Notice that even though only black and white are used, a gray tone is produced if you consider the entire column of type as a whole. This effect can be used in line media illustrations.

Illustrations which contain varying values of gray, in addition to black and white, fall into the group identified as tone media. The grays in this media may vary continuously from black to white.

203. State techniques associated with line drawing.

Line Drawing. Many media can be used to render illustrations. Any substance which achieves the desired effect can be used. However, for illustrations that must be reproduced, preserved, and executed quickly and economically, the number of media is sharply limited. Since illustrations in line media generally fit into this category, there are only a few types of line media. Among these media are ink, pencil, crayon, shading sheets, and special surfaced paper.

Pen and Ink. All of the techniques that use ink as a medium depend on the opacity of the ink and its capacity to contrast sharply with the ilustration surface. India ink is most commonly used because it is permanent, waterproof, opaque, and nonreflective. The ink is applied with open or closed reservoir-type pens and dip pens which come in a variety of points. A few of the most common types of pens are shown in figure 1-3. Descriptions of these pens and their uses are given below:

- A croquill is a small cylindrically shaped pen and very flexible. This type of pen is used to produce very fine or very thick lines. The weight of the line is determined by the amount of pressure applied to the drawing surface.
- Quills are large feathers from a goose or turkey, and are shaped and used as pens. They produce a very flexible line that may vary from thin to very thick.
- Artist pens are available in a variety of sizes in degrees of flexibility. Some are very flexible and are used to draw very thin or very thick lines. Others are stiff and are used where a variety in line-width is not desired.

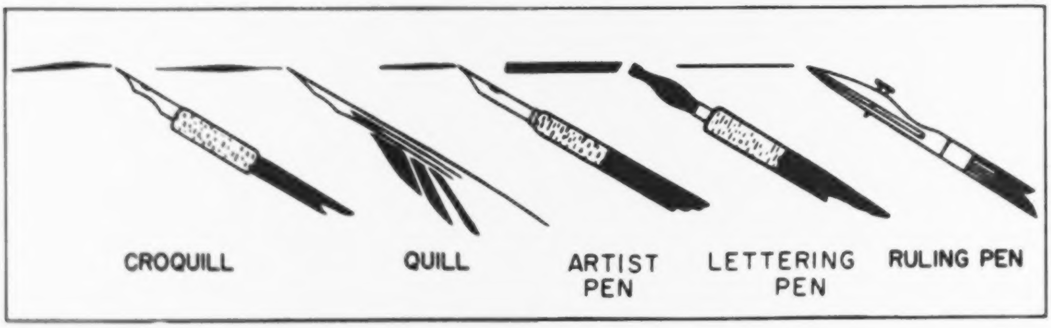

Figure 1-3. Typical drawing pens.

- Lettering pens are available in many different sizes and four different shapes. The four shapes are round, oval, square, and chiseledge.
- Ruling pens are used to produce straight lines of uniform width when used with a straightedge and to produce curved lines when used with an irregular curve.

Outline rendering. The technique of outline rendering is relatively simple, yet it is not mastered without considerable practice. Outline drawings in ink should be clear, sharp, and of consistent density and width. The quality of a pen line is affected by many conditions and practices. The pressure on the pen, the smoothness with which the stroke is begun and ended, the evenness of ink flow, and the condition of the illustration surface affect the line. The angle at which the pen is held, the retracing of lines, and the number of times the pen is removed from and replaced on the illustration surface affect the quality of the inked line. The degree of pen pressure determines to some extent the width and the consistency of the line and the evenness of the ink flow. The number of times that the pen is lifted and replaced and the amount of retracing that is done affect the consistency and sharpness of the line. Pen strokes that are not smooth, or which stop and start with uneven pressure, will give uneven, rough lines.

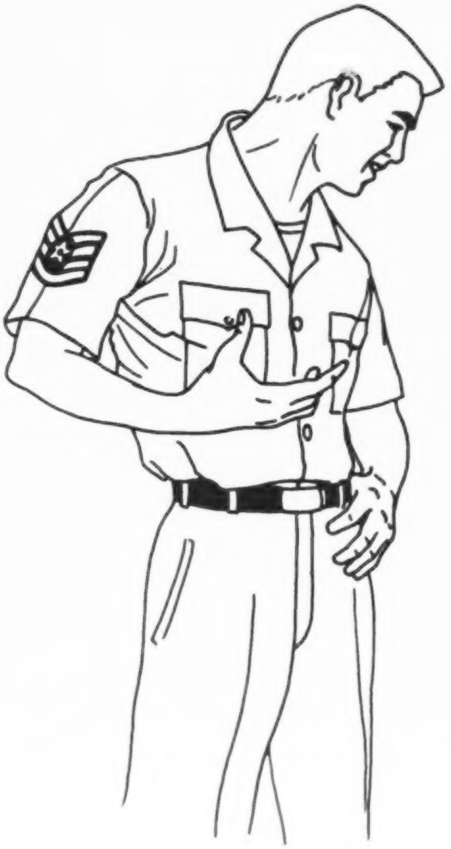

Figure 1-4. Pen-and-ink illustration by the outline technique.

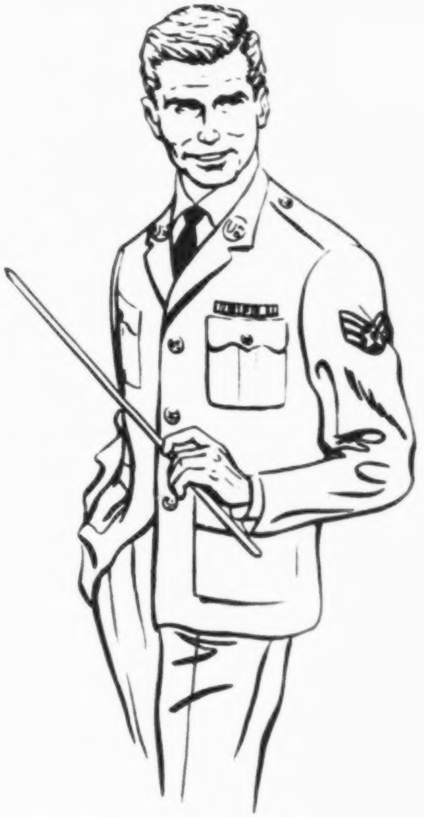

Figure 1-5. Pen-and-ink illustration by accenturated outlined techniques.

Requisites of good pen-and-ink techniques are that the lines be solid black, free of feathered or bleeding edges, and consistent in width, and that adjacent lines join without irregularities, breaks, or overruns. An example of outline drawing is shown in figure 1-4. This figure shows the characteristics of outline drawing.

One of the important characteristics of outline drawing is the ability to remain two dimensional. Notice in figure 1-4 that the illustration remains flat, even though it shows an airman in aplified perspective which would normally give the impression of three dimensions. This is an important feature to remember, especially when you include a human figure in an illustration and wish to have it remain subordinate to other parts of the illustration.

When you wish to give more three dimensional qualities to an outline drawing, you can use an accentuated line technique. This technique is shown in figure 1-5. Notice how varying the width of the line gives this illustration a feeling of three dimensions. That is, the figure of the airman seems to stand out from the background of the page. This feature is quite apparent when you comdpare the illustrations of figures 1-4 and 1-5.

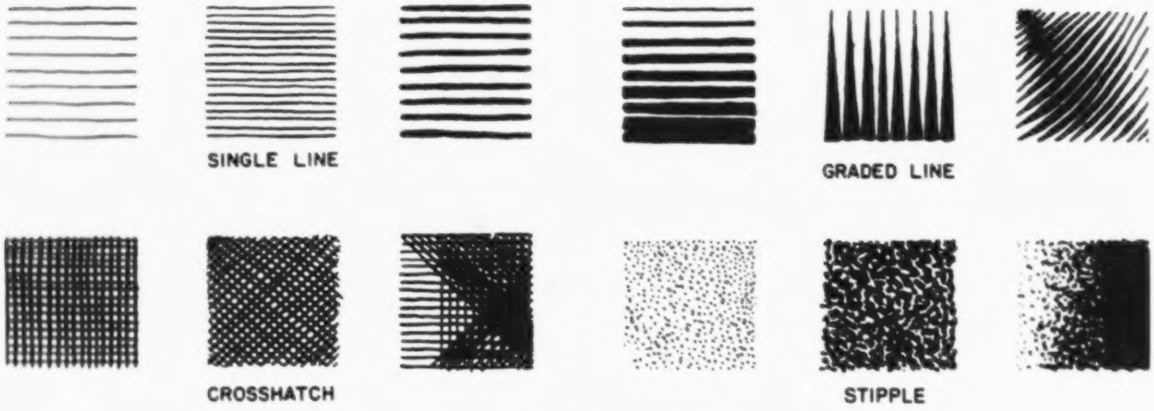

Figure 1-6. Examples of tone and shading by line techniques.

Line rendering of tone. Drawing tone or shade by means of line is an extension of outline drawing. The effect of tone or shade can be produced by drawing a series of parallel lines. Some of the tonal effects that can be achieved by line are shown in figure 1-6. To give the effect of flat tone, the lines must be parallel, equally spaced, and uniform in width. Darker tones may be produced by either placing the lines closer together or by using thicker lines. Of course, each technique produces an effect that is quite different from the other. Combining the two techniques (that is, using a greater number of thick lines) produces still darker tones.

An entirely different tonal effect is produced when two series of parallel lines are crossed. This technique is called "crosshatching." The lines may cross perpendicular to each other or at any angle. However, each technique produces a different effect. The direction in which the lines are drawn also affects the appearance of

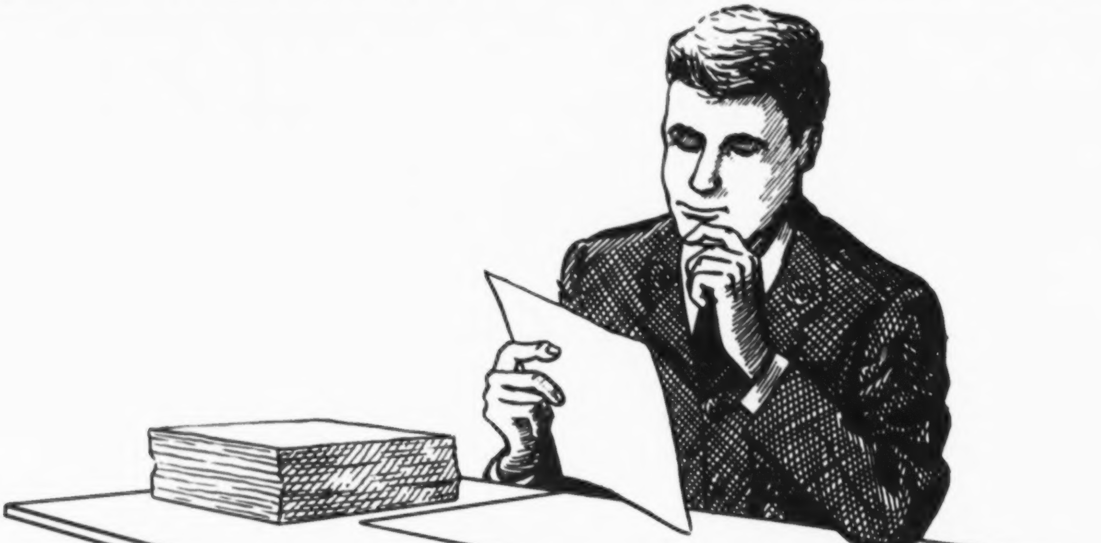

Figure 1-7. Pen-and-ink illustrations showing tone and shading by line techniques.

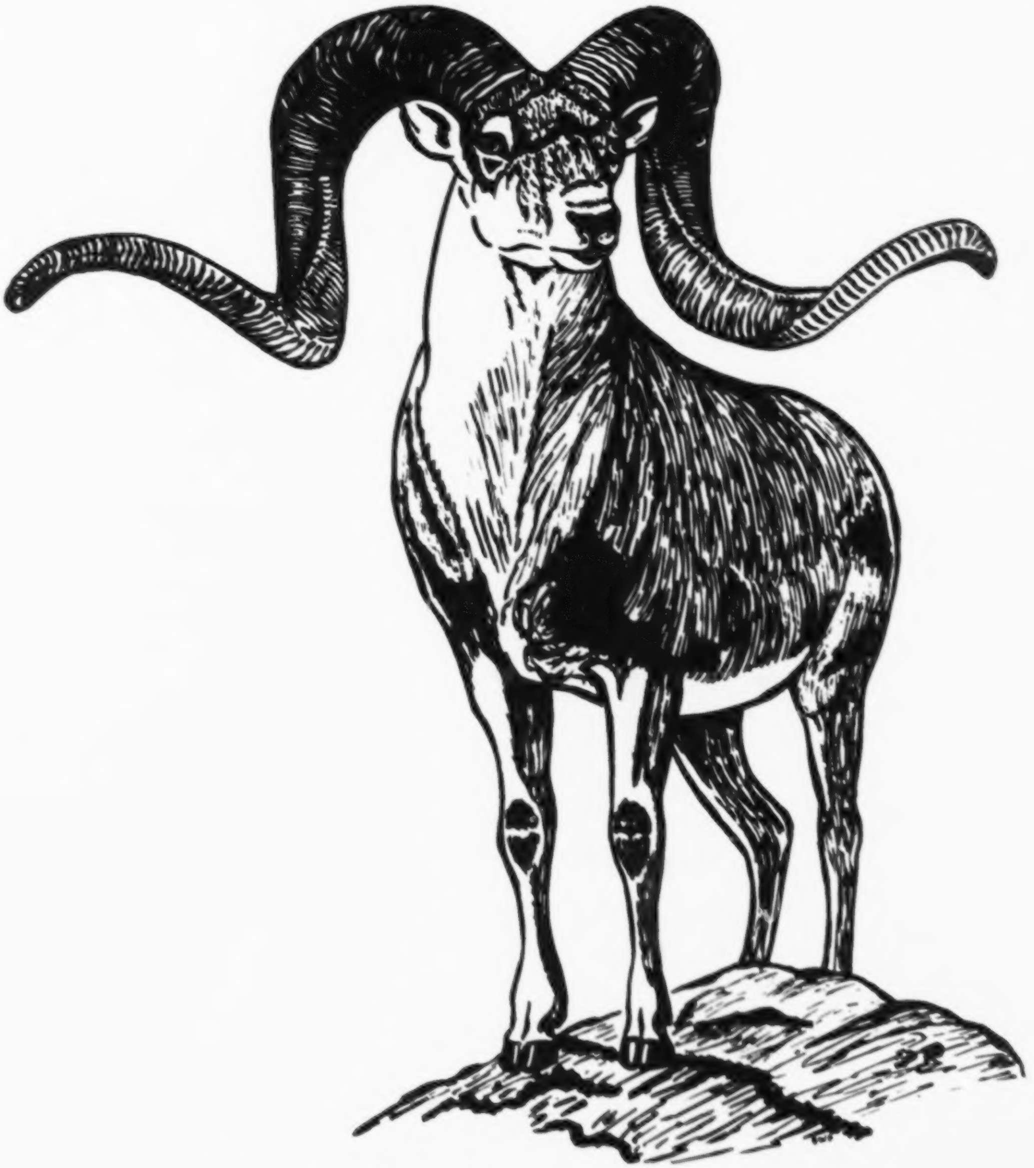

Figure 1-8. Pen-and-ink illustrations
by graded line technique.

the crosshatching. Notice the difference in the effect of the examples shown in figure 1-6 when perpendicular crosshatching is drawn in horizontal and vertical directions rather than when drawn in diagonal directions. Also notice in figure 1-6 that darker tones are obtained by drawing additional lines in a different direction.

The use of graded lines is another technique of pen-and-ink medium. This technique uses lines of varying width to produce the effect of tone or shade. Three different methods of obtaining tone are shown in figure 1-6. One method uses lines of various thickness to show gradation from light to dark. Another method uses lines which vary from thin to thick. The final example shows the effect obtained by varying the pressure on a very flexible pen.

The bottom three examples of pen-and-ink techniques shown in figure 1-6 present an entirely different quality of tone. Here the lines are so short that they appear as dots. The dots are distributed at random until the desired tone is obtained. As you can see, the stipple technique not only gives a tonal effect, but also suggests texture.

Now let's see how these line-tone techniques can be used in illustrations. Figure 1-7 shows the use of line as shade to give the face and hands of the figure portrayed a feeling of form. It also shows how crosshatching can be used to represent the value of a material that has a definite color.

Figure 1-8 illustrates the use of graded lines. Here graded lines are not only used to give the subject of the illustration form, but are also used to add character to the subject. The same technique could not be used for the subject portrayed in figure 1-9. The subject in figure 1-9 calls for a soft, more delicate touch. Notice, however, that the lines in both illustrations are applied

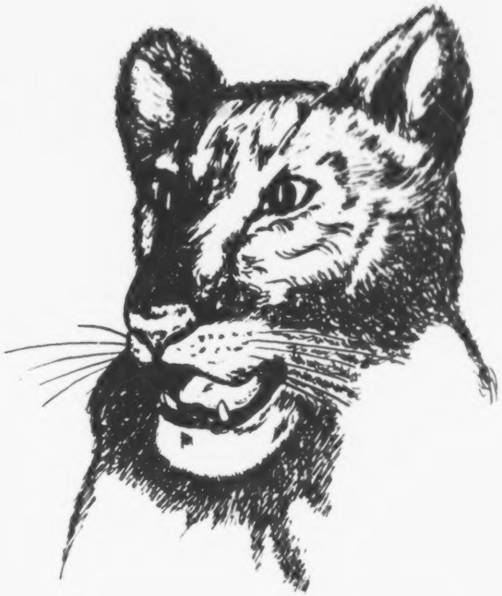

Figure 1-9. Pen-and-ink illustrations by crosshatch technique.

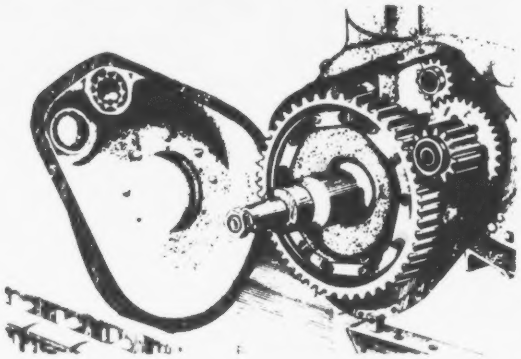

Figure 1-10. Pen-and-ink illustrations by stipple technique.

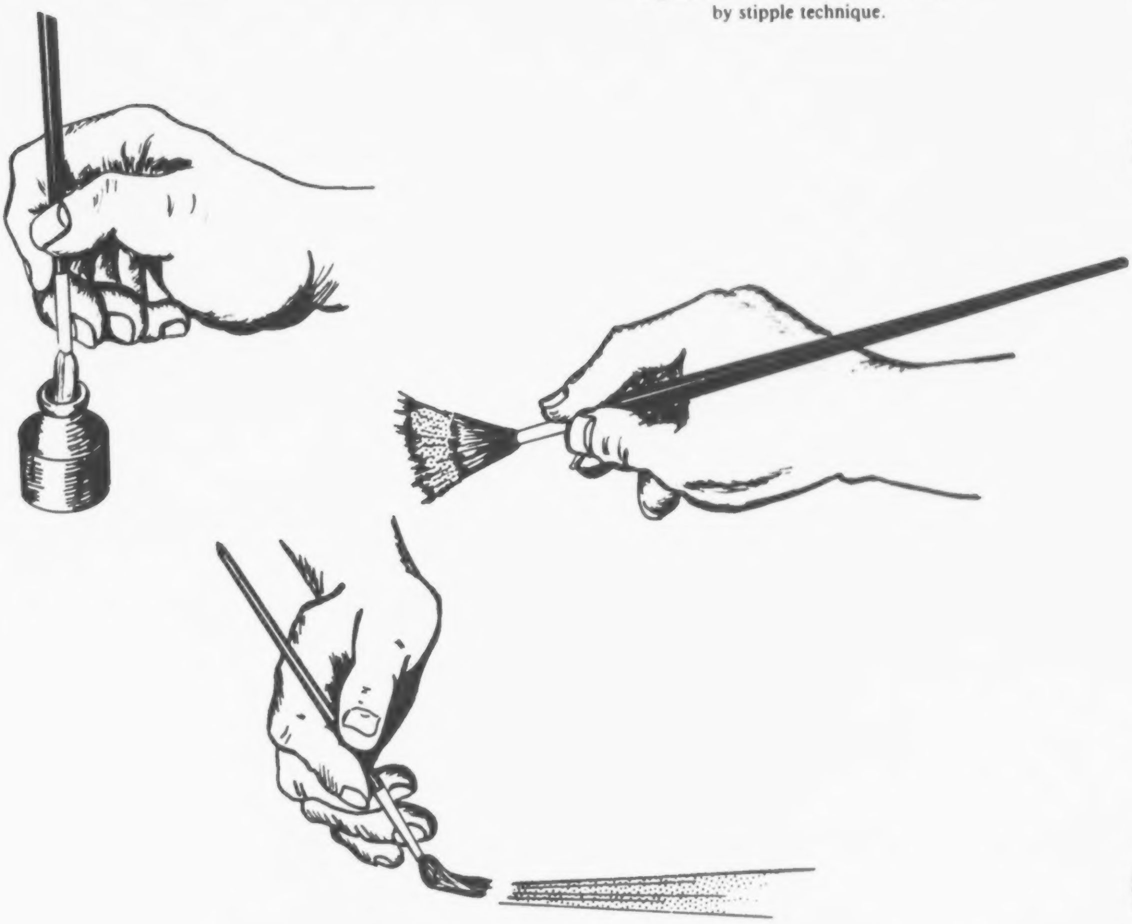

Figure 1-11. Dry-brush application.

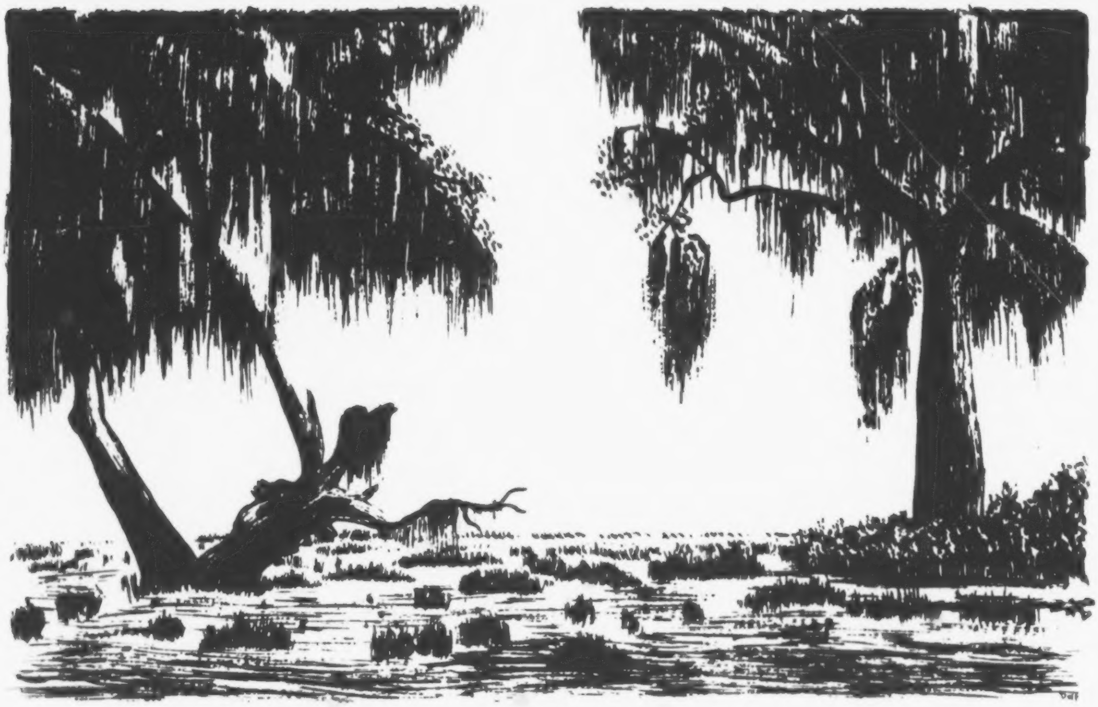

Figure 1-12. Illustrations by dry-brush technique.

to the form of the subjects. They follow the contour of the form.

Notice how effectively the stipple technique is used in figure 1-10. Not only is the form of the molded parts portrayed, but shadow and texture are also represented. Where the parts are machined, a line technique gives a smooth, flat representation.

Brush and ink. Some illustrators prefer to apply ink to an illustration with brush rather than a pen. This method is very adaptable to accentuated line techniques and to large solid areas of black. India ink is very hard on sable brushes; therefore, you should not use your best brushes for this type of work. Be sure to clean your brush thoroughly after using it with ink.

A brush can be used for other purposes than drawing lines. Ink, lampblack, and black tempera paint can be applied with a dry-brush technique. This technique consists of applying the media in a rather thick state. That is, the media is almost dry. The application of this technique is illustrated in figure 1-11.

To apply ink or another medium by the dry-brush method, you dip your brush into the medium, spread the hairs apart by pressing the brush down on a palette or piece of scratch paper and then rotating the brush slightly, lightly wipe off the excess medium on a blotter or piece of paper, and then drag the tips of the hairs across the drawing paper. You should use an upward motion at the end of the stroke. Figure 1-12 shows a typical example of an illustration drawn with the dry-brush technique.

Exercises (203):

1. On what two qualities do all techniques using ink depend?

2. What type of pen has the ability to produce a very fine or very bold line?

3. Outline drawings in ink should be ______________, __________________ and of __________________ density and width.

4. What is the technique called when two series of parallel lines are crossed?

204. State the need for textured surface when producing a line media drawing with pencil.

Pencil. Lithographic, carbon, or other types of black pencil can be used with the same line techniques as those

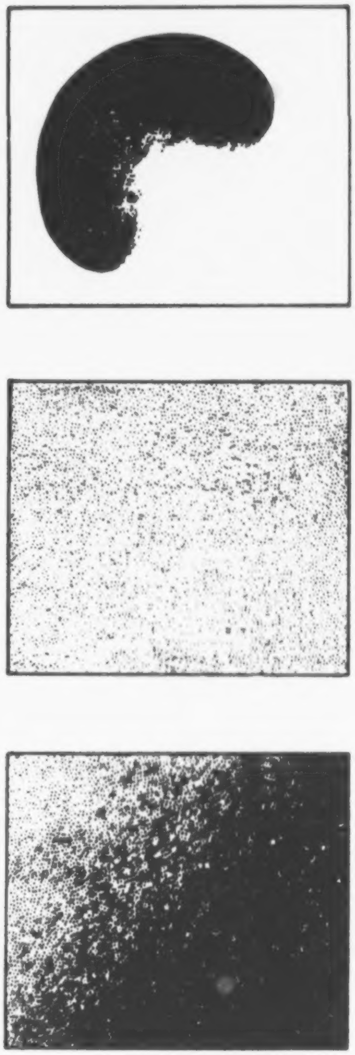

Figure 1-13. Drawing on textured board.

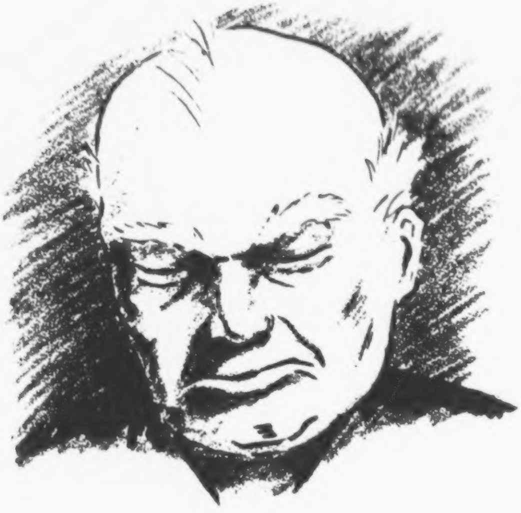

Figure 1-14. Illustrations on texture board.

used with pen and ink. However, since the lines produced by these media are not as sharp and do not have the contrast that ink lines have, a different technique is usually used in a line media illustration produced with pencil or crayon. The drawing is applied to a textured surface. Figure 1-13 shows the principle of application.

the paper on which the sample techniques of figure 1-13 were originally drawn has a special surface. the paper is not only textured with a chalky surface, but the texture has a definite pattern. In the top example, pencil was applied to a solid area and a knife was used to scrape away part of the top surface. This technique gives a pattern of white on black. A black on white pattern, as shown in the middle example, is produced by moving a pencil or crayon lightly over the surface. The side of the pencil or crayon is used, and the action is continued until the desired value is obtained. As you can see in the bottom example, a graduation of value from light to dark can be obtained by continuing the process and by gradually increasing the pressure applied to the medium until the surface of the darkest area is entirely covered.

The black-on-white technique can be used on any rough or grained surface. The illustration shown in figure 1-14 is an example. The results are satisfactory as long as only the high parts of the surface are covered.

Exercise (204):

1. To be classified as a line media illustration, a pencil or crayon drawing is usually produced on what type of surface?

205. List the types and special features of prepared shading media.

Prepared Shading Media. Although prepared shading sheets are not used to render a complete illustration, they are often used as a timesaving device and for special effects. Two different types of shading sheets are available—the transparent film patterns and tones and the chemical-development patterns and screens.

Chemically developed shading media. The chemically developed shading medium consists of papers and boards that contain invisible patterns and screens which are made visible by the application of chemicals. The process is simple. The invisible patterns or screens are

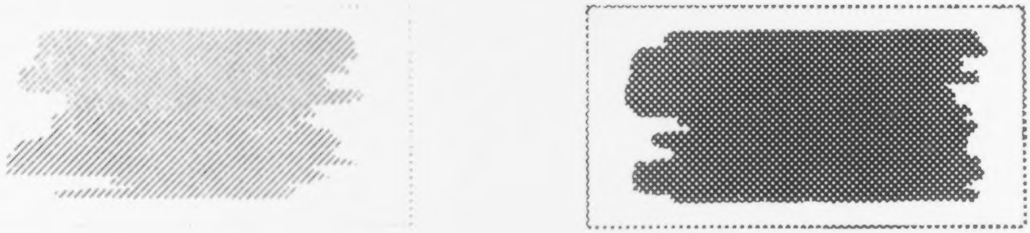

Figure 1-15. Application of chemically developed shading sheets.

brought out by applying a special colorless liquid by means of brush or pen. Both single-tone and double-tone patterns are available. A sample of each type is shown in figure 1-15. The double-tone surface contains both light and dark tones that are developed with two different solutions.

The chemically developed method of obtaining tone is fairly fast and economical when compared with the same effect obtained with pen and ink. This technique is relatively simple and easy to master. An example of the effects achieved by this technique is shown in figure 1-16.

Transparent film patterns and tones. Transparent film patterns and tones are usually printed on clear cellulose acetate and may have an adhesive back. The film comes in a variety of line patterns for use in line-rendering and for shading. Screens and tones are used to give a halftone rendering effect. Examples of both line and tone patterns are shown in figure 1-17.

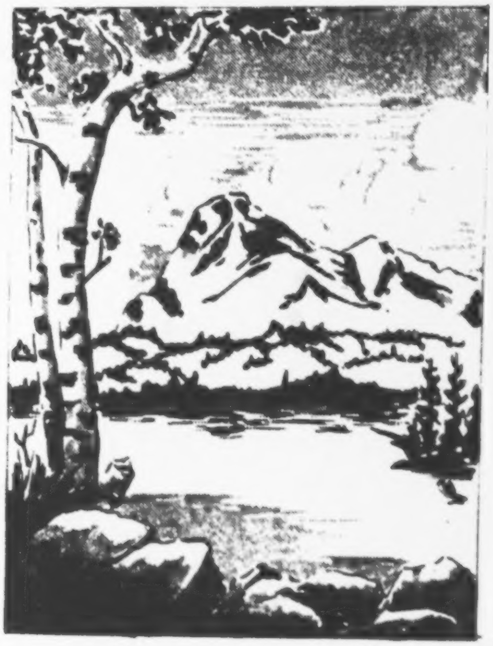

Figure 1-16. Chemically developed shading sheet illustration.

Figure 1-17 shows how the transparent film is applied. First, cut off a piece of film large enough to cover the area where the line pattern is to be applied. Then, apply the film over the entire area, even including the intermediate areas where a line pattern is not desired. Now with a sharp knife, cut around the area where a pattern is not wanted and peel off the unwanted portion of the film. When cutting, be careful to cut only through the film and *not* to cut the surface of the illustration board. The film may not come off in one piece, because it tears easily. In our example, it has not been entirely removed from the subject.

Figure 1-17 shows the use of transparent film as a background. However, the media can be used as line-rendering, as shown in figure 1-18. In this illustration, a film of one pattern is used to produce different tonal effects. To produce these effects, the entire area was covered with the original pattern. The additional pieces were applied to various smaller areas. These smaller pieces were applied over the original pattern, but slightly offset from it. When the desired tone was obtained, the pieces were pressed into their permanent position.

Various patterns can be created by overlapping the same pattern or different patterns of transparent film. A few of the countless numbers of patterns that can be created in this manner are shown in figure 1-19.

Exercises (205):

1. What are the different types of prepared shading sheets?

2. What special feature does prepared shading media have that other shading techniques do not have?

3. How are unique patterns created with shading sheets?

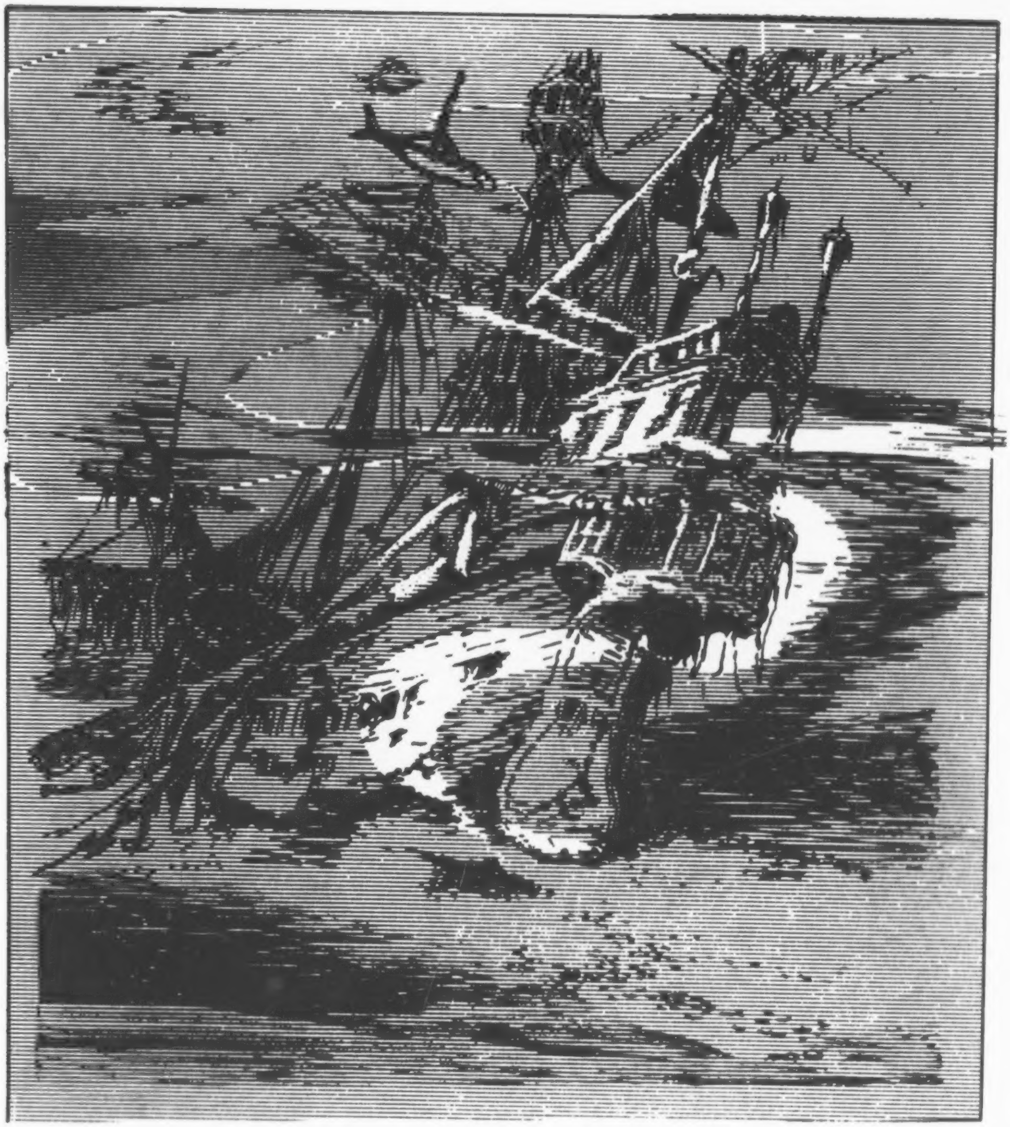

Figure 1-17. Application of transparent shading sheets.

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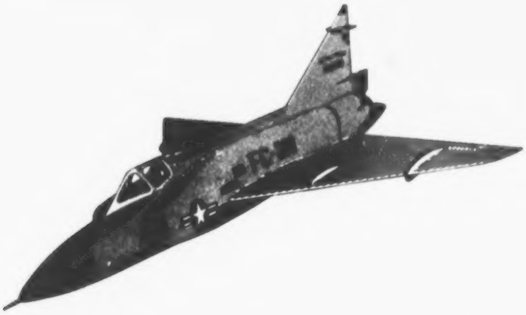

Figure 1-18. Transparent shading sheet illustration.

206. Describe the properties of pencil, crayon, conte', and charcoal in relation to tone.

Pencil, Crayon, Charcoal, and Conte'. Pencil, crayon, carcoal, conte' and other similar media are not ordinarily thought of as media for finished artwork. However, they are very useful both for roughing-in of ideas and for comprehensive layouts. Since the techniques of using these media are the same, we will discuss only the pencil medium.

In addition to lead or graphite pencils, other pencils, such as carbon and lithographic, are useful in illustrating. The lead pencil leaves a shiny surface, whereas a carbon pencil gives a matte finish, which gives a richer black.

As you learned earlier, lead is graded from extremely hard to very soft. The hardest lead produces a very light gray tone, while the tone varies progressively darker with each softer grade. This tonal effect, using three different grades of pencil, is shown in figure 1-20.

Dark, mat-finished pencils come in various degrees of softness. All give an appearance of blackness when used on a paper with a slight tooth or texture, as compared with the gray effect of lead pencils.

Pencil can be used on any kind of paper stock, though a shiny paper does not take hard lead very well. A rough paper will naturally take the pencil on the higher ridges, resulting in a granular effect. This effect is shown in part A of figure 1-21. Where necessary, this effect can be altered by rubbing down the area with a paper stump or with the tip of a finger, as shown in part B. Darker tones can be added to a light area by going over the area with a softer pencil. Highlight can be brought out with a kneaded eraser, as shown in part C.

When pencil is used on rough paper to cover only the high ridges, as in the illustration shown in figure 1-22, the illustration can be reproduced as a linecut. This is the printer's term for an illustration produced by a line technique. However, if the illustration is produced by rubbing or covering parts of the entire surface of the paper as in figure 1-23, a halftone process of reproduction must be used to reproduce it. This is a process which reproduces the illustration by breaking the tones into tiny dots. Illustrations printed in newspapers are reproduced by this process.

Exercises (206):

1. What effect is produced by rubbing a pencil area with a paper stump or the tip of your finger?

2. How do lead or graphite pencils differ from carbon or lithographic pencils as they relate to the tonal media?

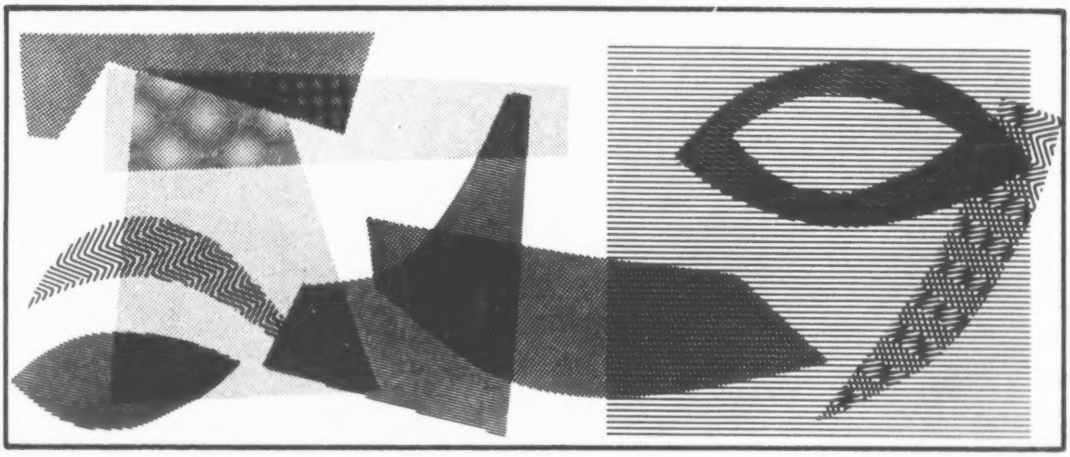

Figure 1-19. Overlapping transparent shading sheets to create different patterns.

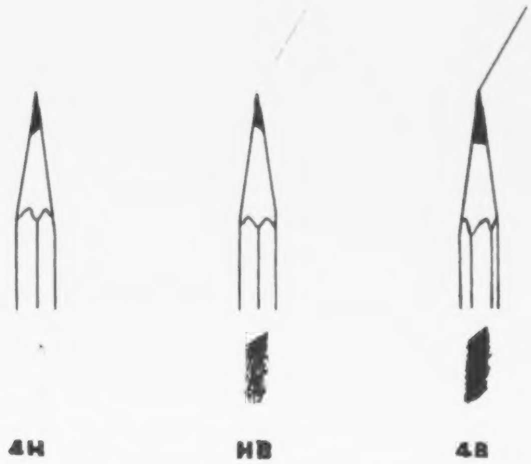

Figure 1-20. Effects of different grades of pencils.

207. State the procedures for laying a wash.

Transparent Wash. Wash is a transparent watercolor made by diluting either lampblack, India ink, or Chinese stick ink. Lampblack is easiest to use, but India ink has the advantage of being waterproof, making it possible to lay one wash over another without picking up the one underneath. Chinese stick ink is prepared by rubbing the stick around in the porcelain dish with water until the desired amount is dissolved. This is strained through a wet cloth to get rid of any solid particles that may be left.

Wash is applied with round or flat red sable brushes. This wash (or ink) lines are drawn with a croquill pen or very small brush. After use, brushes should always be rinsed out in clean water, pointed up carefully, and laid flat where the hairs will not be disturbed. Brushes should be washed occasionally in warm water and a mild soap, rubbing the brush gently in the palm of the hand, then rinsing it thoroughly in lukewarm water.

Flat wash. To lay a flat wash, the paper should be taped down to a drawing board, and the board should be tilted to about a 30° angle. The first step in laying a flat wash is to mix enough watercolor diluted to the desired value to cover the entire area over which the wash is to be laid. For best results, wet the area with clear water and allow it to dry until no moisture can be seen on the surface. Then load the brush with the watercolor. Starting at the top of the area, take an even, moderately fast stroke across the paper, holding the brush quite flat so that most of the hair touches the paper. The color is carried along at the heel of the brush, and a pool along the bottom edge of the stroke is formed. Remember that wash is floated on, not rubbed in. Upon reaching the end of the stroke, as shown in figure 1-24, bring the wash down without lifting the brush; then start back across the paper in the opposite direction, allowing a slight overlap with the previous stroke. This is continued over the area to be covered. Before the brush loses its pool of color, quickly dip it into the watercolor previously mixed and continue the next stroke. When the wash is finished, the pool of color at the bottom is picked up by squeezing the brush dry and running the brush lightly over the pool of color. If this pool of color is not picked up, the color will settle and form a dark line along the bottom of the washed area.

Graded wash. Laying a wash graded from dark to light value, like the one shown as part B of figure 1-24, is accomplished by starting out with the brush loaded with the dark tone and dipping it into clean water after every stroke or two, diluting the wash as you proceed.

A wash from light to dark can be accomplished in a similar manner. Starting out with clear water, you add a little color after each stroke.

Special techniques. Figure 1-25 shows some of the special effects of different wash techniques. The top example shows the technique of softening the edges of a wash. This can be done either on a wash applied on the

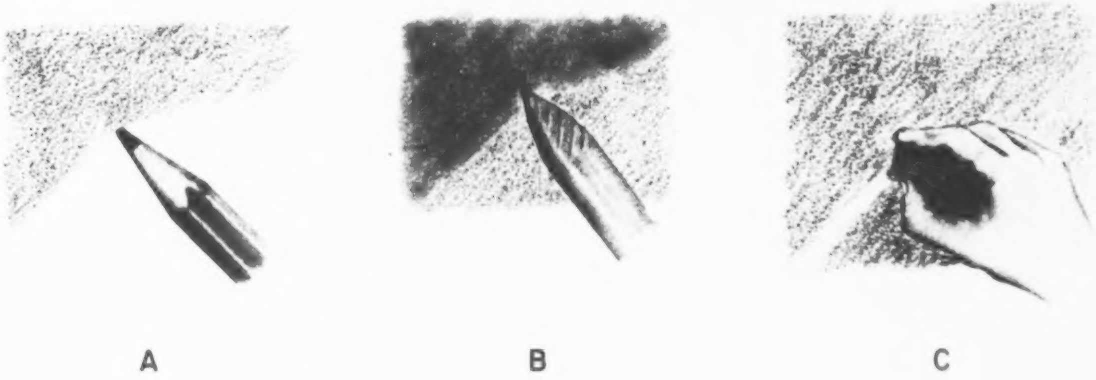

Figure 1-21. Application of pencil techniques.

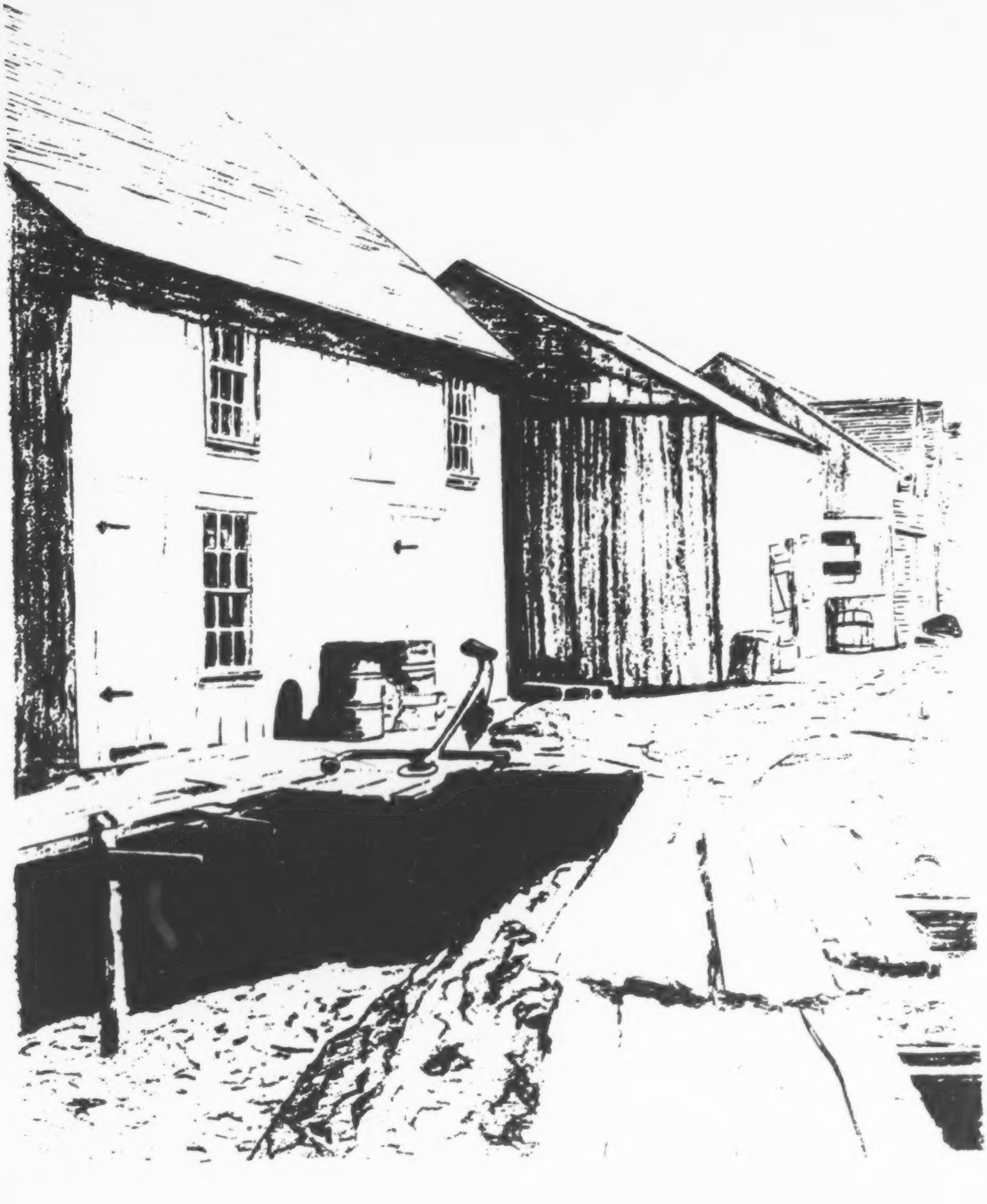

Figure 1-22. Pencil illustration for linecut.

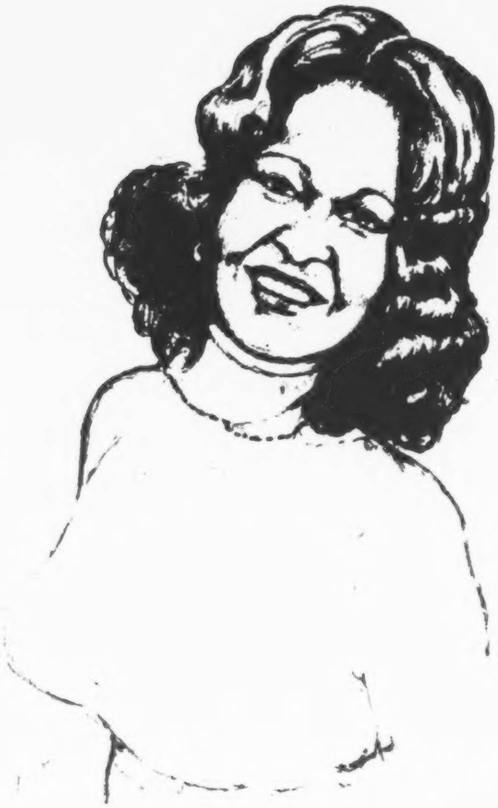

Figure 1-23. Pencil illustration for halftone.

Figure 1-24. Application of transparent wash.

surface of the paper, as shown, or on a wash applied over a previous wash. After laying the wash, you rinse the brush out quickly in clean water and then drag the tip of the wet brush slowly across the edge of the still wet wash. The brush should be held flat so that the water wets the paper a short distance below the wash, allowing the color to run down into the wet area.

Very soft, fluid effects (characteristic of watercolor) can be obtained by working into a wet area. To produce example B, the paper was first moistened with clear water; then a light wash was applied while the area was still wet. When the wash was nearly dry, the spots were dapped in with a loaded brush. Working over wet paper increases the softness of the edges, but also decreases the control of the wash. When the wash is dry, sharp, crisp accents can be added, as shown in example C.

When the wash must terminate in a very sharp straightedge, masking tape is laid along the edge and the wash is brushed right up to it. Be sure that the wash does not collect along the tape; do not remove the tape until both the wash and tape are dry. A liquid masking medium or rubber cement can also be used as a mask over the area where you do not want wash. The results shown in example D of figure 1-25 were achieved in this manner. The advantage of using a mask is that the wash can be laid evenly over the entire area. After the wash is dry, the masking medium is picked up, leaving the protected area without wash.

Exercises (207):

1. What is a wash illustration?

2. Why must a wash be started at the top of the illustration?

3. How are soft, fluid effects obtained in a transparent wash?

4. What is the easiest method of terminating a wash with a shart straightedge?

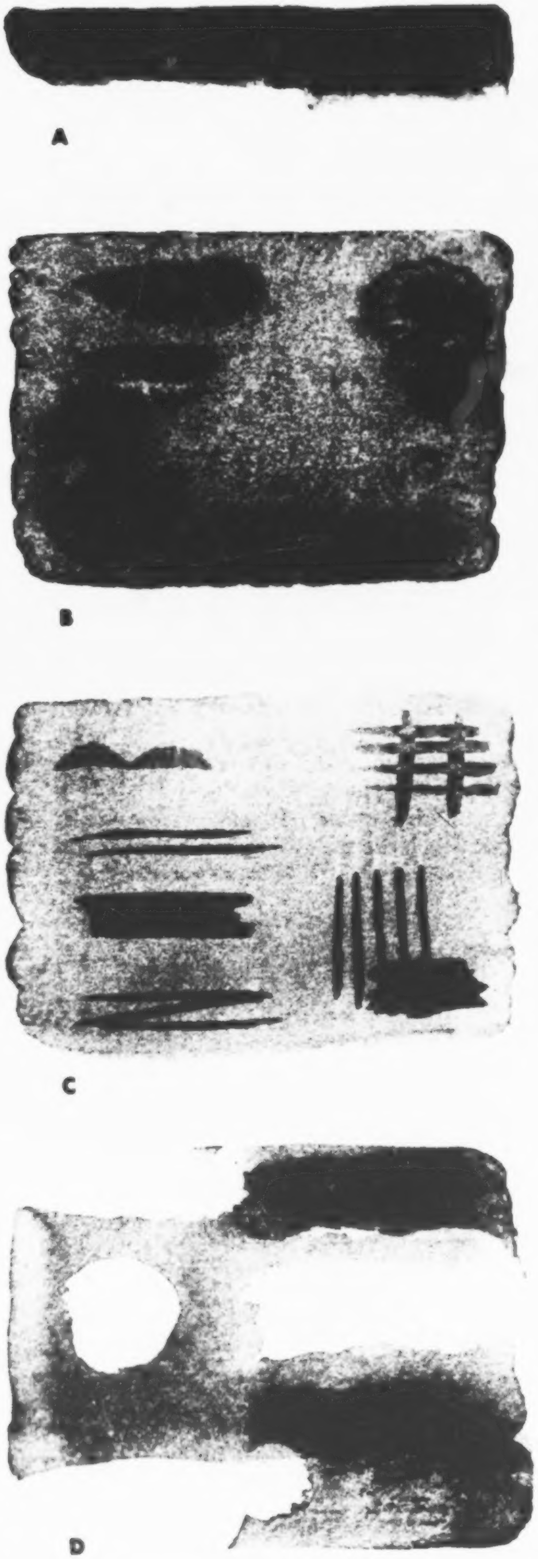

Figure 1-25. Special effects of transparent wash.

1-4. Color Theories and Techniques

Color is so constantly in evidence all around us that we give it very little attention. We merely accept it, as we do sunshine and shadow. Although we appreciate its beauty, we do not consciously realize what an important part it plays in our lives. But whether we realize ir ot not, color influences us during practically every waking moment.

The important part that color plays in our lives is shown in many ways. We are more inclined to be cheerful on bright, colorful days than when the sky is gray. We are more contented in harmoniously colored rooms of reasonably distinct hue than in those which are drab. Yet, we are disturbed by interiors that are gaudy and crude. We like the out-of-doors for its green trees, blue skies, and purple hills. Even our food is more attractive and more appetizing than it would be if it were a neutral tone.

In addition to its artistical and psychological values, color serves us in many practical ways. Color aids us, for instance, in identifying one object from another at a glance. It helps us to know whether fruit or vegetables are unripe, ripe, or spoiled; whether food is raw, sufficiently cooked, or overdone; and whether objects are extremely hot or cold. In fact, there is hardly a phase in our existence that is not affected in some way by color.

Is there any wonder then why color is so important to you as an illustrator? You, who must portray people and things in a world of color, must learn to appreciate and understand color far more than those who merely enjoy it. You must learn to use it in many ways: to attract and hold attention, to lead the eye, and to please, as well as to give many other desired effects.

To use color effectively, you must possess a basic knowledge of color theory. You must know the qualities of color, how different colors are related to each other, how to mix colors, and how to select colors that go well in combination. You can learn these fundamentals by studying this chapter. In addition, this chapter includes techniques of using color in the following media: oil, acrylic, watercolor, tempera, pastel, pencil, crayon, and multimedia.

208. Define light dispersion and the light spectrum.

Relationship of Light and Color. From the beginning of time, man has been interested in color and has continuously sought to wrestle its secrets from nature. However, it was not until the advent of science that intelligent research and experimentation was conducted. Especially in the last two centuries, physicists, physiologists, and psychologists have studied the problems of light and color and the processes of vision. Chemists, too, have made progress in the discovery and perfection of pigments.

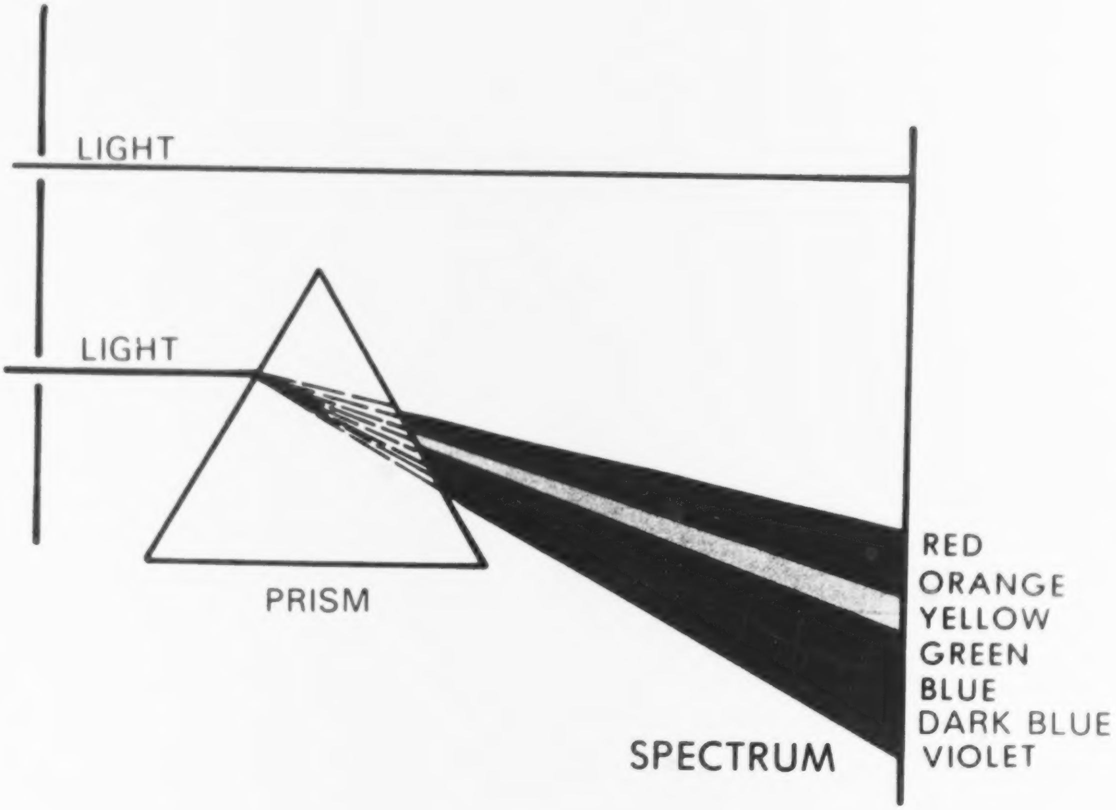

Figure 1-26. Dispersion of light.

We are indebted to Sir Isaac Newton who, in the 17th century, discovered that light consisted of many rays (each of which, when allowed to reach the retina of the eye, produces the sensation of a distinct color); and that the fusion of all the sensations generated by the mixture of rays gives the sensation of white. We also learned that light comes from its source (the sun) as a wave motion traveling at a speed of approximately 186,000 miles per second. The sensation known as color is produced by the action of these rays of light upon the optic nerve. The waves vary in length, and this variation causes the different colors.

Newton made his discovery by performing an experiment which is shown in figure 1-26. In a darkened room, he admitted a beam of sunlight through a slit in a window shade and allowed it to pass through a prism. This separated the light into a long line of colors such as those we see in a rainbow. This separation of light into its element is called *dispersion,* and the resulting band of color is known as the *spectrum*. The colors of the spectrum arrange themselves in order of their wavelengths, the long waves being less refracted than the short waves. Starting with red, which has the longest and slowest vibrating wave of any ray visible to the human eye, the colors follow in this order: red, orange, yellow, green, blue, and finally violet.

Newton also demonstrated that the separated colors can be recombined into white light. He proved this by using another prism and also be receiving them onto mirrors or lenses so curved that they convey the colors to a single spot.

Thus, long ago man learned that light is the source of color and that white light is made up of varying rays, each capable of producing the sensation of a distinct color. It is obvious, then, that when light is present, color is present and that when light is absent, color is absent. It follows that the nature of light influences the nature of color. Objects look different under daylight, electric light, gas light, colored light, etc.

With this as a background, let us consider why one object looks red and another green. If we glance at an object (excepting self-luminous, fluorescent, or

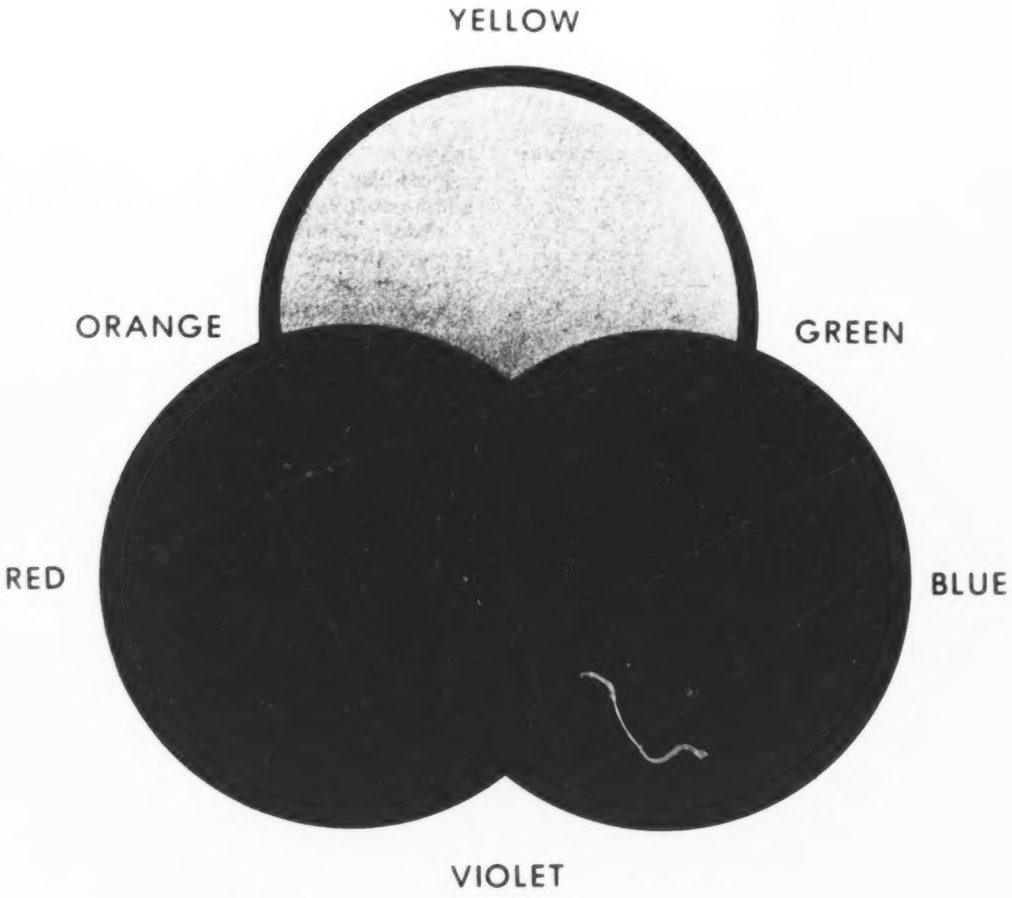

Figure 1-27. Subtractive process of color.

transparent ones), we see the object because some of the light cast upon it is reflected into our eyes. It is easy to understand why the object appears bright when it is in strong light and appears indistinct when it is in dim light. It is not so easy to understand why one object appears red and another green until we learn that surfaces exercise a selective power on the light. Every surface decomposes the particular light by which it is illuminated. Each surface absorbs some of the light rays while it reflects or scatters other rays in all directions.

A red object, as it decomposes the light that falls upon it, absorbs or annihilates all the rays except the red. These red rays are reflected. Thus, we see the object as red. A green object has the power to absorb all of the rays except the green. A white object is merely one which reflects a large percentage of all rays so balanced as to give the effect of an absence of color—white. A black object is one that absorbs nearly all of the light rays.

Other investigators of light made additional contributions to our knowledge of light and color. Sir David Brewster concluded after long experimentation with pigments and color glasses that light was made up of three primary colors—red, yellow, and blue waves. Dr. Thomas Young, and later Professor Helmholtz, working with spectral colors, conceived the theory that instead of red, yellow, and blue, the true primaries were red, green, and blue (blue-violet).

The important factor that we learned from these theories is that the laws that apply to light do not apply to pigments. Obtaining different colors by means of light is an additive process, while obtaining colors from pigments is a subtractive process. For example, in color television, all colors are produced from the primary colors, red, green, and blue. When the red dots of a color TV screen are illuminated, we see the area as red. If the green dots in this area are also illuminated, the combination of red and green appears yellow. If the blue dots are also illuminated, the area appears white. By adding the colors red, green, and blue in the correct proportions, all colors can be produced.

The subtractive process of pigments works entirely different. As shown in figure 1-27, the three primary colors—red, yellow, and blue—when mixed in the proper proportions, produce the remaining colors of the spectrum—orange, green, and violet. Notice that when all three colors are mixed together, the result is black rather than white, as in mixing light.

The important fact to remember about this discussion of light and color is that, although light and color are inseparable, we must treat color by pigmentation as a separate and distinct process. Since it is color by pigmentation in which we are most interested, when we refer to color from now on, we will mean pigmentation color unless we specify otherwise.

Exercises (208):

1. Who discovered light rays?

2. What is dispersion?

3. What is a spectrum?

209. Compare the qualities and the relationships of color.

Color Qualities. If we look at any given color analytically—the red of an apple, for instance—we discover that it possesses three outstanding characteristics of qualities—hue, value, and intensity.

Hue. The quality by which we recognize one color from another and which (we suggest by its name) is called hue. The apple is red; red is the hue (or name) of the color.

We can alter the hue of a color by mixing another color with it. If we mix red pigment and yellow pigment, we produce orange pigment. This is a change in hue.

Value. Next comes the quality by which we discern lightness or darkness in a color. This we call value. It is by value that we are able to discriminate between light red and dark red.

We change the value of a color by mixing something lighter or darker with it. If we mix black or white with a color, we change its value but not its hue. This change can probably be best shown by means of watercolor. If we add water to red pigment, we make the value lighter, but we do not change its color or hue. It appears as pink which is still a red hue. It is not orange or green or blue.

We call a color in its full, natural strength *normal color* or a color of normal value. If the color is lighter than normal, we call it a tint. If it is darker than normal, we call it a shade. These latter terms are so often abused that it is better to use the word *value*—such as "a light value of red" rather than "a tint of red" or "a dark value of blue" rather than "a shade of blue." Tone is a word of such ambiguous meaning that it is best to employ it only in a general way to include all normal colors, tints, and shades.

Intensity. The third quality of color relates to strength. Some colors are strong and some are weak. The quality by which we distinguish between them is called *intensity*, or *chroma*. If we remark that an object is saturated, is colorful, or is strong in color, we refer to its intensity.

We can change the intensity of a normal color by mixing with it a pigment that tends to dull or fray it. We can change intensity without changing value or hue by adding neutral gray of equal value.

Color Relationships. The solar spectrum (as projected onto a screen by means of a prism) is extremely brilliant. It is light itself. If we try to represent this spectrum with even the purest pigments obtainable, we cannot approach its intensity. Each pigment absorbs many of the light rays that come in contact with it and tends to reflect portions of hues other than the dominant one. White paper reflects only a little more than half of the light that falls upon it.

As you know from our previous study of light and color, the spectral hues red, green, and blue-violet are classified as primary; and by mixing these three hues in proper combination, all other spectral hues can be produced. These primaries, in properly balanced mixture, also produce white. But in dealing with pigments, approximations of these spectral primaries do not prove primary. If we mix red and green, for instance, we get gray instead of the yellow as is the case in spectral mixture. You cannot produce normal yellow by mixing any other colored pigments. You cannot produce white by mixing any combination of colors.

Primary colors. Various authorities select different pigment colors as primary. Perhaps the most widely used primary concept, and by far the easiest to understand, is the red, yellow, and blue concept of Brewster. From these three primary colors, almost any desired hue can be mixed.

Secondary colors. By mixing any two primary colors, we can produce a full range of intermediate hues. The hue that is midway between the two primaries is called a secondary color. For example, if we mix varying proportions of red and yellow, we obtain a full range of oranges. The orange that stands midway between red and yellow is a secondary color. In the same way we can produce green by mixing yellow and blue in the appropriate proportions and can produce violet by mixing red and blue. These three secondary colors—orange, green, and violet, together with the three primaries—give us six leading colors. Most coloring sets will include at least these six colors.

Some books say that mixing equal parts of primary yellow and primary blue will produce secondary green. This is not always true. Yellow, though extremely intense, is light in value. Blue is dark, but less intense. In equal mixture, therefore, one may outweigh the other, and a normal green may not result.

Tertiary colors. By continuing the mixing process further, you can obtain the three tertiary colors. Tertiary colors are a combination of the secondary colors. The three tertiary colors are olive (green and violet), russet (violet and orange), and citron (orange and green). Experimenters in the field of color have invented an extremely valuable device commonly known as the color wheel. An example of one type of color wheel is shown in figure 1-28. A color wheel is really a simple scale for measuring hues. Although there is no arbitrary rule as to the number of colors in a wheel, a 12-hue wheel is convenient since it exactly accommodates the 3 primaries, 3 secondaries, and 6 tertiaries.

By saying that such a wheel is a scale for measuring hues, we by no means classify it as a scientific apparatus. The approximate measurement of any hue can, however, be quickly judged by the eye if the hue is referred to the hues of the wheel for comparison.

Complementary colors. The color wheel can also be used to show another color relationship—complementary colors. Before we use the wheel to determine or to show the relationship of complementary colors, let's go back to the study of light to get a clear definition of the term "complementary."

Recall that we see an object because that object has the ability to absorb some of the light that falls on it and to reflect the rest of the light. The rays absorbed by the object are said to be complementary to those reflected because if the absorbed light could be combined with the reflected light, white light would be produced. Or, if we take the spectral colors, we find that blue-green is the complement of primary red because, when these colors combine, they produce white light. Likewise, when blue-violet and yellow or green and purple are combined, they produce white light. Therefore, red and blue-green, green and purple, and yellow and blue-violet are complementary spectral colors.

The importance of these facts about complementary spectral colors is that we can draw valuable parallels in terms of pigmentation. For example, if we mix together our pigment primaries, we get gray instead of the white produced by spectral mixture—this difference being

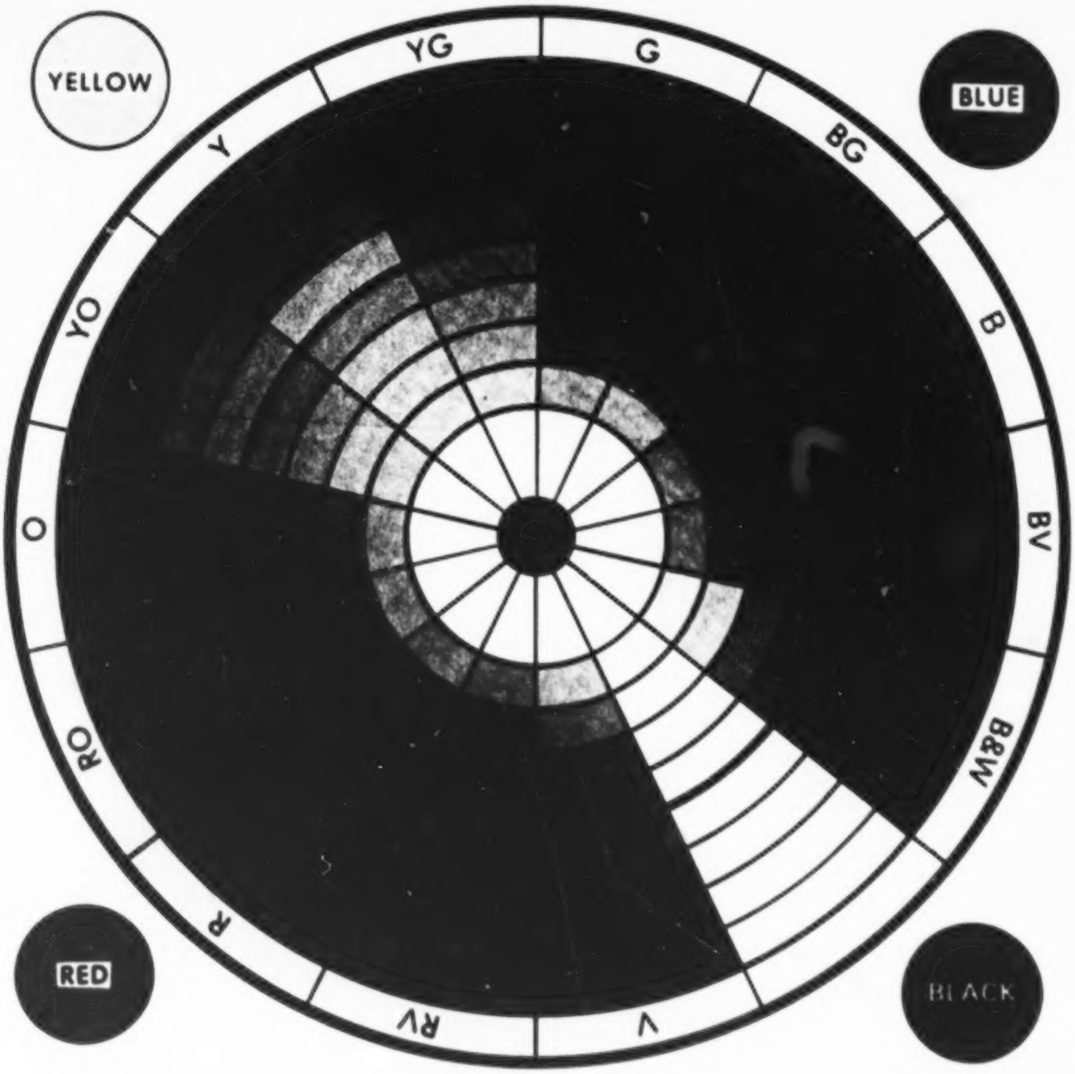

Figure 1-28. Color wheel.

mainly due to the dullness or impurity of pigments when compared to light.

Pigment complements can be identified in much the same manner as the complements of spectral colors. By mixing primary red with primary blue, we obtain a secondary—violet. This is the complement of the third primary—yellow, and vice versa. In other words, the secondary obtained by mixing any two primaries is the complement of the third primary. It follows that if a primary is mixed with the secondary that is its complement, the result will approximate neutral gray; since the secondary is made up of the other two primaries, the three primaries are actually being mixed. Further (and this is the wonder of the color wheel to which we have been leading), any hues exactly opposite on a well-prepared color wheel are complimentary, as you can see in figure 1-29.

We cannot overemphasize the prominent position these complementary hues have in work with pigments. You should use figure 1-29 to memorize the principal pairs. This will be very useful in mixing colors. When a color and its complement are mixed together, each tends to dull or neutralize the other; but when placed side by side, each emphasizes or accentuates the other. Thus, complements have the power to destroy and to reinforce, according to how they are used.

Let us examine the destructive characteristic of complements and see how we can use it. Suppose you have mixed a wash of orange and it is too bright for your purpose. Mixing it with water will make it lighter, but not duller. How can you modify its intensity? By adding gray? Yes, but the use of gray often has a deadening effect. Instead, add complementary blue. This will dull the orange but will not destroy its richness. In the same way, if you have painted a green hillside and it seems too vivid, lay a pale wash of red or red-violet over it.

As an example of the reinforcing characteristics of complements, suppose that you are painting a building that is in bright sunlight. You can enhance the brilliancy of the yellows and oranges by opposing them with blue or violet shadows.

Value. The easiest approach to the study of color-value relationships is through comparison with black and white. In black, we have the lowest of all values—black standing for the absence of light. In white, we have the highest value that our paper and pigments permit—white representing the maximum presence of light. This gives us two predetermined extremes. By mixing black with white in varying proportions, we can obtain innumerable intermediate values of gray. It is customary to estabish a limited number of progressive steps or intervals. If we use seven steps of gray plus black and white, we form a value scale like the one shown in the center column of figure 1-30. This scale can be used very successfully in comparing the value relationship of the 12 colors of the color wheel.

If we divide the 12 colors of the wheel into 2 equal groups and arrange them opposite to the gray values, as shown in figure 1-30, we can quickly compare the values of the colors with the values of the grays. Notice that these values have been given names on the scale. Also notice that yellow has the same value as the gray identified as high light; yellow-orange and yellow-green have the same value as light; orange and green match with low light; red-orange and blue-green with middle gray; red and blue compare with high dark; and violet has the value of low dark. Remember that the colors shown are at full intensity. Of course, if we use tints and shades of the various colors, we can create separate scales for each color. It is obvious that we could not get many tints of yellow or many shades of violet because of their nearness to the value limits of white and black.

Temperature. Colors have a natural temperature value associated with them, and are grouped into two categories, warm and cool. Warm colors are generally red, orange, and yellow. The cool colors are green, blue, and violet. Warm colors appear to advance in space whereas cool colors appear to recede. These temperature properties must be considered in the effective use of color.

Interaction of Color. Whenever two colors are placed next to each other, an automatic interaction takes place. This interaction is called the law of simultaneous contrast. By using the law of simultaneous contrast, you can make a weak red appear redder by placing it next to a green. Simultaneous contrast can also be used to change the value and hue of a color, (red-orange placed on orange will appear red).

Contrast. If we arrange colors (this includes black, gray, and white) side by side so that one is seen against a larger area of another, they tend to modify one another. In other words, colors are modified in appearance by their proximity to other colors. This modification can be seen in figure 1-31. Let us first consider modification in terms of gray. Notice that the two discs, which have the same value, appear to be of different values because their immediate surroundings have a different effect upon them. The apparent change in value is not the only way in which the discs are affected. There is also an apparent change in size. The disc surrounded by the darker value appears slightly larger than the one surrounded by the light value of gray. This is known as the radiation effect.

Value is not the only factor which is affected by environment. If you place a small square of neutral gray on a blue background, the gray seems to take on an orange cast. The same gray against orange shows a hint of blue. This is quite evident when you use large squares of blue and orange placed side by side and lay a piece of tracing paper over the whole area.

As a striking test, lay small green discs in the centers of two adjacent large squares, one light yellow and the other dark blue, as represented in figure 1-31. The green against the yellow seems darker in value than against the blue and appears slightly blue-green in hue. The green against the blue seems slightly lighter and appears slightly yellowish. Not only do the two small green areas apparently change, but the yellow in contrast with the green and blue seems slightly orange, and the blue in contrast with the yellow and green appears a bit purple. This test demonstrates that colors are influenced in hue by adjacent colors, each tinting its neighbor with its own

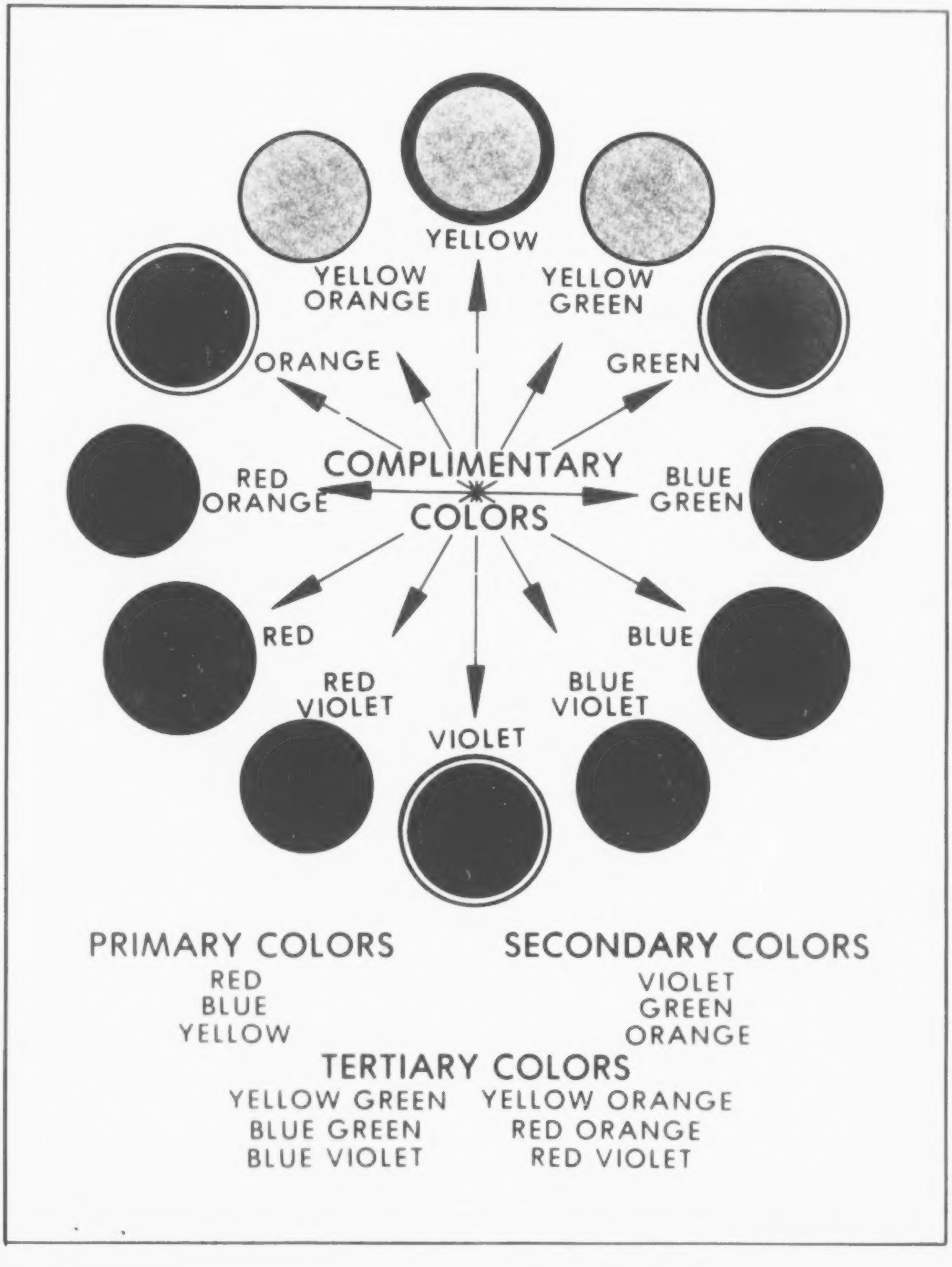
YELLOW
YELLOW ORANGE
YELLOW GREEN
ORANGE
GREEN
COMPLIMENTARY COLORS
RED ORANGE
BLUE GREEN
RED
BLUE
RED VIOLET
BLUE VIOLET
VIOLET
PRIMARY COLORS
RED
BLUE
YELLOW
SECONDARY COLORS
VIOLET
GREEN
ORANGE
TERTIARY COLORS
YELLOW GREEN
BLUE GREEN
BLUE VIOLET
YELLOW ORANGE
RED ORANGE
RED VIOLET

Figure 1-29. Complementary color scale.

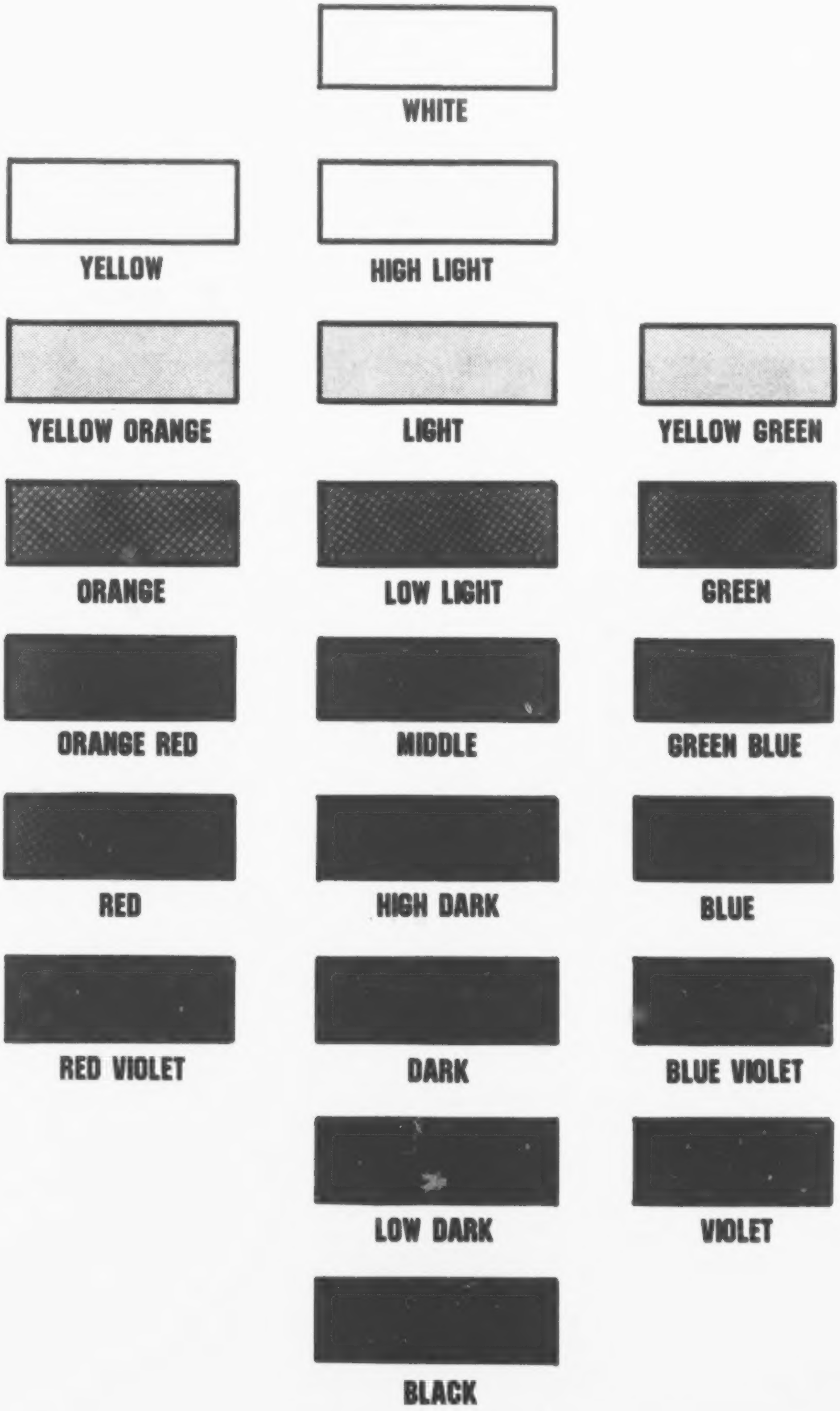
WHITE
YELLOW
HIGH LIGHT
YELLOW ORANGE
LIGHT
YELLOW GREEN
ORANGE
LOW LIGHT
GREEN
ORANGE RED
MIDDLE
GREEN BLUE
RED
HIGH DARK
BLUE
RED VIOLET
DARK
BLUE VIOLET
LOW DARK
VIOLET
BLACK

Figure 1-30. Color value scale.

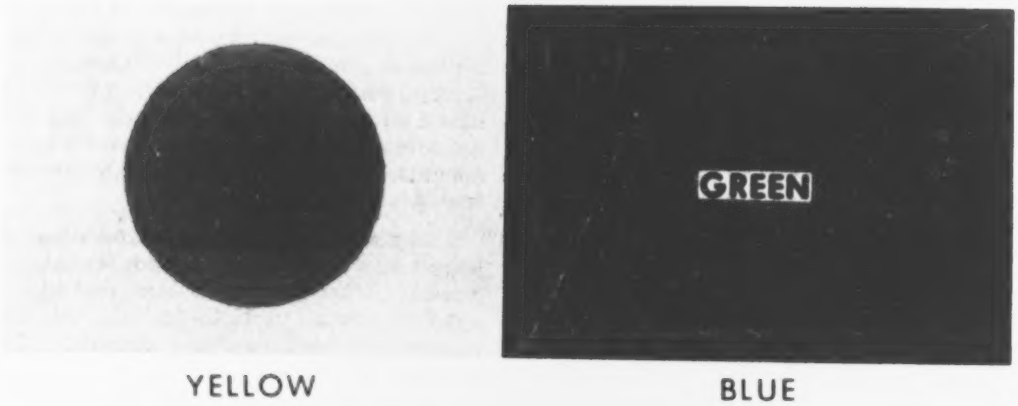

Figure 1-31. Influence of surrounding colors.

complement. Intensities, as well as values, are affected by environment. If two complementary colors lie side by side, each seems more intense than by itself.

Exercises (209):

1. Match the terms in column A with the quality of color they most nearly describe or with which they are most nearly associated in column B.

Column A	*Column B*
___ (1) Tint.	a.Hue.
___ (2) Lightness or darkness.	b.Vaue.
___ (3) Name.	c.Intensity.
___ (4) Chroma.	
___ (5) Shade.	
___ (6) Strength.	
___ (7) Color.	
___ (8) Normal color.	

2. Why don't we use the same primary colors in pigments that we use in spectral colors?

3. Designate the two primary colors listed in column B which are mixed together to produce each secondary color listed in column A.

Column A	*Column B*
___ (1) Green.	a.Red.
___ (2) Orange.	b.Yellow.
___ (3) Violet.	c.Blue.

4. Why is it convenient to use a 12-hue wheel as a measuring scale rather than a wheel of more or less colors?

5. Where on the color wheel are the complementary colors located?

6. In what way does the environment in which a color is placed affect the color?

1-5. Color Harmony

Certain combinations of colors, whether in nature or art, are agreeable to the eye and mind, whereas others give offense. We call the former *harmonies* and the latter *discords.*

Just as numerous attempts have been made to discover the laws of light and color, great effort has been expended in trying to find the reasons why some color combinations are pleasing and others are not, and to devise laws to insure harmonious use of color. However, in view of our previous discussion on the effects of environment on color, we know that color harmony is not merely a matter of selection, but also a matter of arrangement. Area, oscillation, radiation, texture, and color fitness are all factors that influence color harmony. Therefore, these factors must all be considered when we select color schemes.

210. Associate the terms monochromatic, analogous, complementary, and triad to color harmony.

One Color with White, Gray, and/or Black. The simplest scheme is that of an individual hue used in one value and intensity in conjunction with white, gray, and/or black, and sometimes with silver or gold. A common illustration of this scheme is the booklet printed with black ink on white paper (the type masses giving the impression of gray) and a cover of colored stock.

Schemes of this type seldom give offense. As a rule, if a single color is used with large areas of black, a warm one—red, orange, or rich yellow—is most effective. These colors have a brilliancy and vigor which appear to relate them to black. If such cool colors as blue, blue-green, or blue-violet are used with black, they are at their best when quite intense.

White often impresses us as somewhat warm. If a single color is used against it, a rather dark, cool one gives the happiest contrast. Blue and white have always been a popular combination. For softer effects, the light, warm colors are suitable, though many colors, especially if used as tints, are usually pleasing against white.

Monochromatic. This scheme is merely an extension of the previous one to include all values and intensities of a hue, and is used with or without white, gray, or black. The most frequent illustration, perhaps, is the drawing on white paper with a single color such as sepia, the values ordinarily varying from light tints to dark shades. We might say that the use of one color does not constitute color harmony, since there is nothing with which the color can possibly agree or disagree. Strictly speaking, this is true, and such schemes run the danger of becoming monotonous. However, it is surprising how colorful some such arrangements are. If you wish to get slightly more variety than the strictly monochromatic scheme affords, you can simply add inconspicuous suggestions of other colors.

Analogous. An analogous or, as it is sometimes called, *related color scheme* is made up of colors which are nearby in the spectrum. For example, orange, yellow, and green form an analogous scheme, since they all contain the common factor yellow.

A glance at the color wheel will show you which groups of colors are analogous. If we start with yellow, we note that yellow-orange and yellow-green (which are made up largely of yellow) are particularly close in relationship. These three form a close analogy. If to these we add orange and green, each of which contains some yellow, this entire 5-hue group is analogous. We can even include red-orange and blue-green because both of these contain a slight amount of yellow. Out of the 12 hues of our scale, this gives us 7 hues that are somewhat related due to their yellow content. In arranging analogous schemes, the more of the circle that we include, the greater our difficulties become. Therefore, typical analogous schemes usually do not take in more than one-third or a quarter of the color wheel.

Although analogous schemes are often among the most pleasing and are as easy as any to handle, the very unification which makes them harmonious may at the same time make them monotonous. As an illustrator, you must seek to develop in them sufficient hue interest (as well as variety of value, intensity, and arrangement) to prevent monotony.

One of the easiest means of obtaining interest in an analogous scheme is by placing emphasis on a dominant hue. There are various ways of making a particular hue dominant. You can give it a large area, a dark value (against a light background), a light value (against a darker background), or make it intense.

You can also prevent an analogous scheme from becoming monotonous by introducing complementary accents. Such accents, particularly if brilliant, generally have a power out of all proportion to their size. A single touch of color complementary to one hue—usually the dominant—can give surprising life to an otherwise dull analogous scheme.

Complementary. Under this heading, sometimes known as *harmonies of contrast,* we can include any pleasing schemes which conspicuously introduce opposite colors. In fact, the majority of all color schemes are to an extent contrasting, the contrast usually being developed by means of complements. However, you should not base a color scheme on complementary colors in equal areas and full strength. A large red area and a small green area, for instance, often seem harmonious because the dominant red gives unity to the combination. Likewise, a brilliant red can be employed successfully with a neutralized green, even though the areas are equal, for the red will dominate because of its superior intensity.

Near and split complements. Complements which are only approximate, commonly called *near complements,* seem more pleasing than those that are true complements. The term "near complements" is self-explanatory. Violet is the true complement of yellow, while blue-violet and red-violet are near complements. If we speak of these near complements in their relation of one to the other, we call them split complements, as they are split or separated by the true complement.

Triad. If we base a color scheme on a color and its split complements, or on hues mixed from them, we can obtain a fairly wide range of hues; but none of them will be brighter than the color itself and the two split complements in their full intensity. Sometimes, such a range proves too limited; so in place of these split complements, which are closely related to the complement itself, we use other split complements, each a step further removed. In the 12-color wheel, for example, if we take yellow as a hue to dominate a color scheme and the split complements red-violet and blue-violet prove too dull to hold their own, we can substitute red and blue. In this case, we are using three colors equally spaced on the wheel. We call this a triad.

Though mixtures obtained from triads can be very rich and beautiful, triads by no means guarantee color harmony. The red, yellow, and blue triad is mae up of our three primaries from which we know practically all colors can be mixed—discords as well as harmonies. To get effective results, therefore, you must use one of the three hues as the dominant one and mix a little of it with the other two.

Exercises (210):

1. What colors are considered warm, and what colors are considered cool?

2. Which type of color harmony is most likely to become monotonous?

3. You can prevent an analogous color scheme from becoming monotonous by adding ____________ accents to your illustration.

4. A complementary color scheme is based on ______________________________ .

5. A color scheme which is based on three equally separated colors is called a __________________ .

1-6. Color Media

In order to properly render a color illustration, a basic knowledge of color media is necessary. There are eight basic methods of rendering color: oil, acrylic, watercolor, tempera, pastel, pencil, crayon, and multimedia.

Each medium has a different handling characteristic. An awareness of these characteristics is essential to properly handle these media. We will look at the characteristics of each of the media and see how they differ.

211. Differentiate between the eight methods of rendering color.

Oils. Oil colors are basically what the name implies. They consist of finely ground pigments suspended in an oil base. The paint comes in a tube and has the consistency of a thick paste. The pigments are manufactured from natural pigments, artificial oxides, and dyes on fillers.

The surface used for oils is very important. The surface must have a consistent and rough texture to allow the paint to adhere to it. Therefore, canvas (cotton or linen) is the best surface. However, tempered masonite, prepared pasteboard panels, and oil painting paper may be used. All painting surfaces must be sized and primed before painting.

The colors can be applied straight out of the tube (impasto) or they can be diluted with turpentine and linseed oil and used as a wash (glazing). Brushes and palette knifes are the most common method of applying the paint; however, anything your imagination dictates can be used.

The versatility of oils is its major advantage. Its major disadvantage is the time it takes for oils to dry. Oils are very durable and suitable for murals, portraits, or presentations where permanence is a desired quality. Sufficient production time must be allowed for projects using oils as a medium.

Acrylics. Acrylic colors are pigments that are uniformally dispersed in an aqueous polymer emulsion. The binding vehicle consists of droplets of synthetic plastic resin suspended in water. As the water evaporates, the droplets of resin combine to form a clear film giving an exceptional luminosity and brilliance to the colors. The tough and durable film is highly adhesive, water resistant, flexible, and permanent.

Acrylics are unique in that they can be handled in the same manner as oils, or they may be diluted and used as watercolors. Because acrylics are water soluble, they need no special mediums (such as linseed oil or turpentine) to work with. The polymer resins also dry quickly. This is the major advantage and disadvantage of acrylics. You can complete a painting in less time, but you must know exactly what you are doing. The fast drying time makes acrylics less "forgiving" than oils.

Watercolors. Watercolors, whether transparent or opaque, are made of pure, finely ground pigment mixed with a little gum to make them ahere to the paper. Transparent watercolors are mixed with water and spread over the paper in a wash. This allows the natural luminosity of the paper to show through the pigment. The more water that is used, the more transparent the color will be.

Opaque watercolors include designers colors and gouache. The pigments are mixed with gum and a medium to enable them to completely cover the paper surface. The painting surface plays a very important role; good quality paper is a must for the use of water colors. The paper should be of a medium or heavy weight to keep buckling at a minimum, have a textured surface, and be aborbent.

The techniques for handling watercolors are basically the same as those mentioned earlier for producing a transparent wash using ink. Dry brush and scratching techniques are also used extensively in combination with wash techniques.

Tempera. Tempera is an opaque watercolor that is a heavier and stiffer medium than transparent watercolor. Tempera is often used for illustrating in flat tones. Although tempera is much harder to blend than transparent watercolors, it is much easier to apply in a flat tone.

Pastels. Pastels are finely ground pure pigment and a small amount of adhesive that has been compressed into stick form. These powdery sticks of color are available in three grades: hard, semi-hard, and soft. Brilliant color, soft tones, and smooth blending are characteristic of pastels.

Because pastels are pure particles of pigment with little adhesive, the surface you use it on should have enough texture to hold the pigment particles. A medium weight, rough surface paper is ideal for pastel work. The medium weight of the paper provides a solid, yet resilient drawing surface; and the tooth has a good pigment-holding capability. Pastel paper also comes in assorted colors and tones to accent and compliment your work.

The blending properties of pastel makes this medium ideal for a number of techniques. You can easily lay one color on top of another to achieve a transparent wash effect. The proper use of lines will strengthen the expression of form. You can also rub one color into another to form delicate backgrounds for strongly marked direct strokes used in portraits, still lifes, and landscapes.

Pencil. We have previously discussed the use and qualities of carbon, graphite, and lithographic pencils. They differ very little in use and technique from colored pencils. Colored pencils are made of compressed pigment encased in wood. They are inexpensive, portable, and very versatile.

Transparency is the key to colored pencils. Since the pigment won't smudge or blend as easily as graphite pencils, the transparency of the colors is used to lay one color on top of another to achieve a series of composite hues and values.

A good colored pencil looks thick-leaded, and the mark it makes on the paper is slightly waxy and soft. Its hue has a good buildup. It goes on the paper quickly, uniformly, and brilliantly. Colored pencils having hard, thin leads leave a weak mark, and are brittle, are poor choices for this medium.

Techniques suitable for colored pencil are line and color, crosshatching, tone, tone and line, stippling, sgraffito (scratching), burnishing, and compressed line.

Crayon. Crayons, as you remember from childhood, are sticks of colored wax. Those sticks of colored wax gave you your first experience in color media. The wax base used to hold the pigments makes the crayon difficult to smudge and blend. Crayon is not generally suited for presentation graphics.

Mixed-Media. Simply stated, mixed-media is a combination of any two or more mediums. Mixed-media can be used to enhance a project where a single medium won't achieve the effect you desire. With practice, you can combine any and all of the color media to fit any requirement that you may have.

Exercises (211):

1. What is the major advantage of oil colors?

2. What is the major *disadvantage* of oil colors?

3. Why are acrylics unique?

4. What qualities must good watercolor paper have?

5. What is the difference between tempera and watercolor?

6. What are the three grades of pastels?

7. Why is transparency the key to working with colored pencils?

8. List the properties of a good colored pencil.

9. What is meant by the term "mixed-media"?

Human Form

DRAWING THE HUMAN figure is probably the most rewarding achievement that an artist can experience—when it is done right. On the other hand, it can be one of the most exasperating chores ever undertaken by a human being. You may have concluded from these first two statements that drawing the human figure is extremely difficult—well, it is. Now, we are going to show you in this chapter that it can be made easier than you think by following a few simple procedures.

2-1. Drawing the Human Form

In drawing any form, one must be willing to proceed one step at a time, mastering each step as you go. Each portion of the drawing must be given some special consideration as it compares with the rest of the figure. If you wish to achieve even moderate success in the art field, the drawing of the human figure is a must because 87 percent of all illustrations, posters, and drawings contain the human figure or some portion of the figure in them.

212. Describe the method of measuring the human figure proportions.

Figure Proportions. The human head is used as the basic unit of measurement for proportioning the entire human body. The vertical height of the head, from the chin to the top of the skull, is used for all vertical measurements (fig. 2-1). The width of the head is used to make all horizontal measurements. For example, the average human figure is 6½ to 7 heads high, but the ideal height for any illustrated figure is 8 head units high, and 3 head widths wide.

After the height of the figure has been decided, it should be divided into eight equal parts. This makes the figure slightly taller and slimmer than the aveage person. The rest of the body is then proportional as the figures in 2-2A and 2-2B.

In figure 2-2A, the other seven heads are divided as follows:

- One-third of a head for the neck.
- Two and two-thirds heads for the torso (from the bottom of the neck to the crotch).
- Two heads to the knee.
- Two heads to the soles of the feet.

The male figure is usually taller than the female with the same proportions. The average length of the male-head proportion is about 9 inches. The female-head proportions are between 8 and 8½ inches from the chin to the top of the skull.

These are average proportions for the figure standing in an upright position. Most of the time, you will find that the figure, or some parts of it are foreshortened as in figure 2-3. For the best result, when proportioning the figure, you must rely on your visual perception. Only the human eye can determine the amount of foreshortening necessary, because it is a relative judgment.

Foreshortening is a principle of perspective in which an object seems to change its size and shape because it changes its plane of projection.

The Adult Figure. The structural differences between the male and female are more in the bones and muscle tissue than anywhere else. (See foldout 3, printed as a separate supplement to this volume.) The bones of the female are smaller and smoother than the bones of the male. The female body appears much smoother and less muscular, although the female has the same muscle structure as the male. This appearance is caused by a heavier covering of fatty tissue over the entire body.

Because of the narrower rib cage, shorter and more curved breastbone and a small straighter collar bone, the female's shoulders are not as broad as her male counterpart. The female also has a longer torso, shorter legs with a broader, shallow pelvis. Note the greater distance between the pelvis and rib cage of the female in figure 2-4. Also notice that the male's pelvis and rib cage are about the same width, whereas, the female's pelvis and shoulders are about the same width. These differences are subtle in most cases, but to an illustrator—these are differences that count.

Proportion changes. Proportion changes as the body grows from birth to adulthood. Look at figures 2-5A and 2-5B as we continue this discussion. At birth, a baby's head is quite large compared to the rest of his or her body. At the age of about 1 year, the body from the neck to the feet is about three and one-half times the length of the head. The center of the body at 1 year is across the stomach.

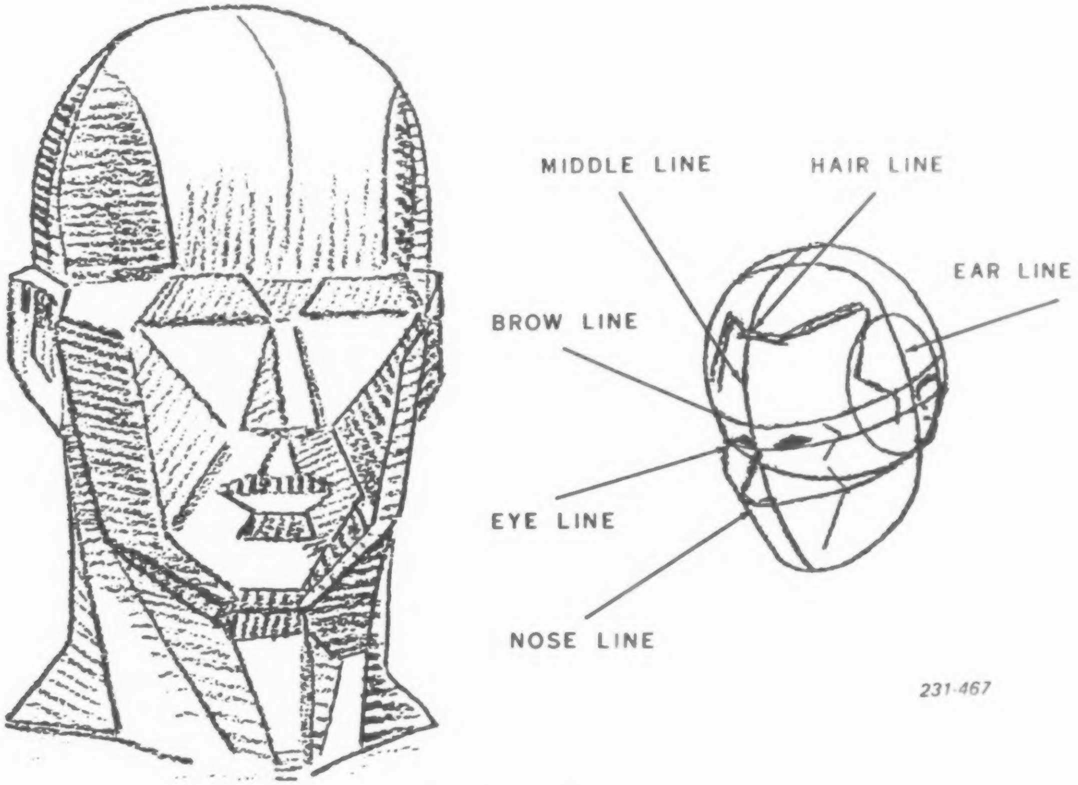

Figure 2-1. Human head.

At the age of 8 years, the overall height of the body is approximately 6¼ heads. The arms and legs are somewhat longer, the head is a little larger, and the center of the body has moved to the hips.

At age 12, the overall figure is 7 heads high, and the centerline is now at the crotch. From this age on, the body broadens out, becomes taller, and assumes most of the characteristics of an adult.

Exercises (212):

1. What is the average ideal height of the human figure?

2. Why does the female body appear smoother than the male?

2-2. Constructing the Human Figure

For the purpose of construction, the human figure may be divided into five component parts: torso, arm, leg, hand and foot, and head and neck. Each of the components, in turn, may be considered to consist of the basic forms or combination of the basic forms.

213. Name and describe the components of the torso.

The Torso. You must study the torso from many angles to fully understand its function. The torso is made up of three masses: the chest, the abdomen, and the pelvis (fig. 2-6). The chest is made up of the rib cage, shoulder, and collar bones. The rib cage is a modified cone-shaped mass with the base below. The upper portion of the rib cage appears broader than it actually is, due to the shoulders and collar bones. This causes the shape of the rib cage to be lost from view. The pelvis is the lower part of the torso that serves as a base for the other parts of the body. The chest and pelvis are fairly stable masses. The epigastrium or the upper portion of the abdomen is a soft, fleshy, and quite movable part of the torso. The three central masses are connected by the spinal column. The only reason for the study of bones and muscles is that the artist has to understand the framework if he intends to build. (See foldout 4.)

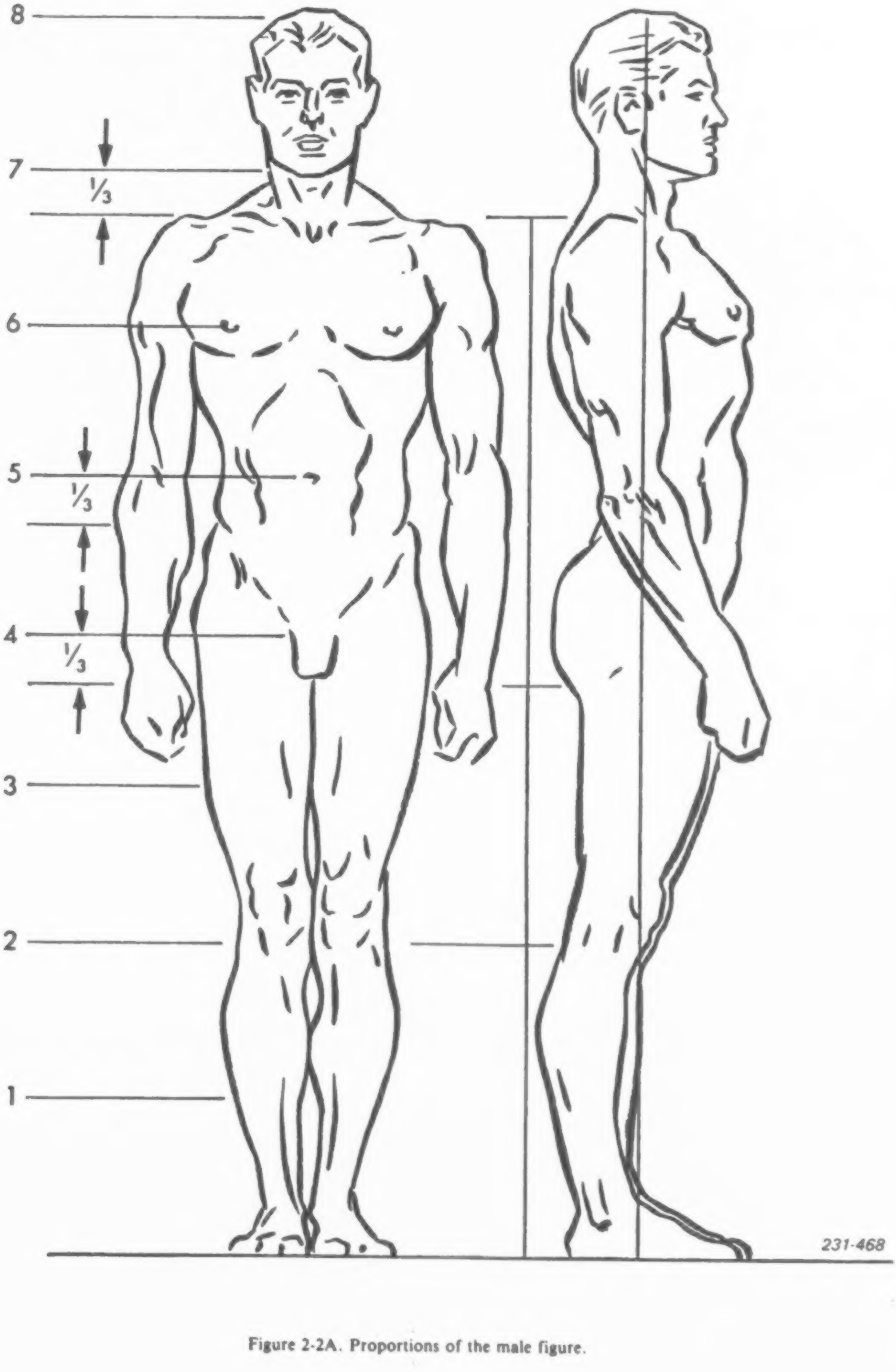
8
7
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Figure 2-2A. Proportions of the male figure.

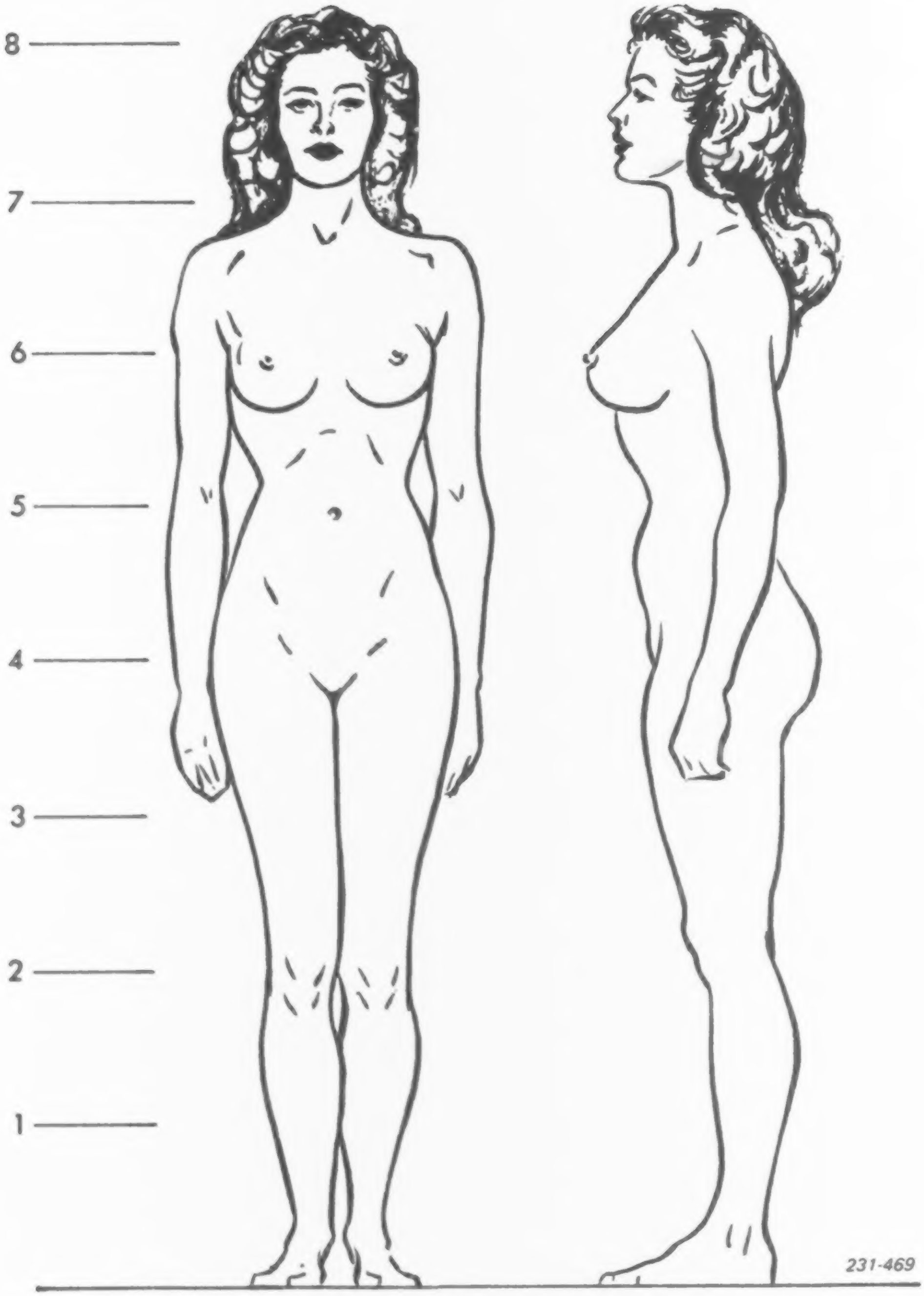
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Figure 2-2B. Proportions of the female figure.

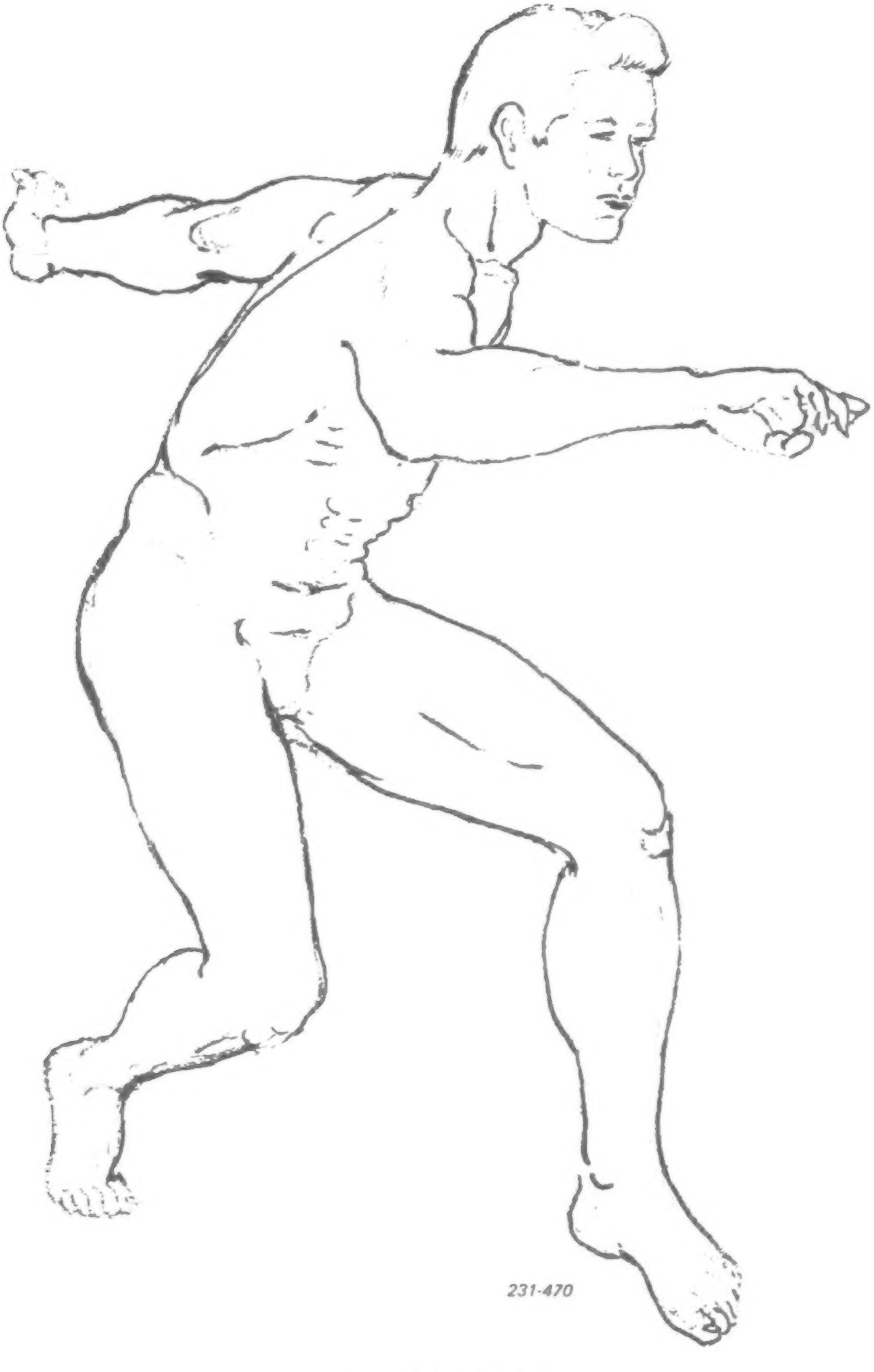

Figure 2-3. Foreshortened.

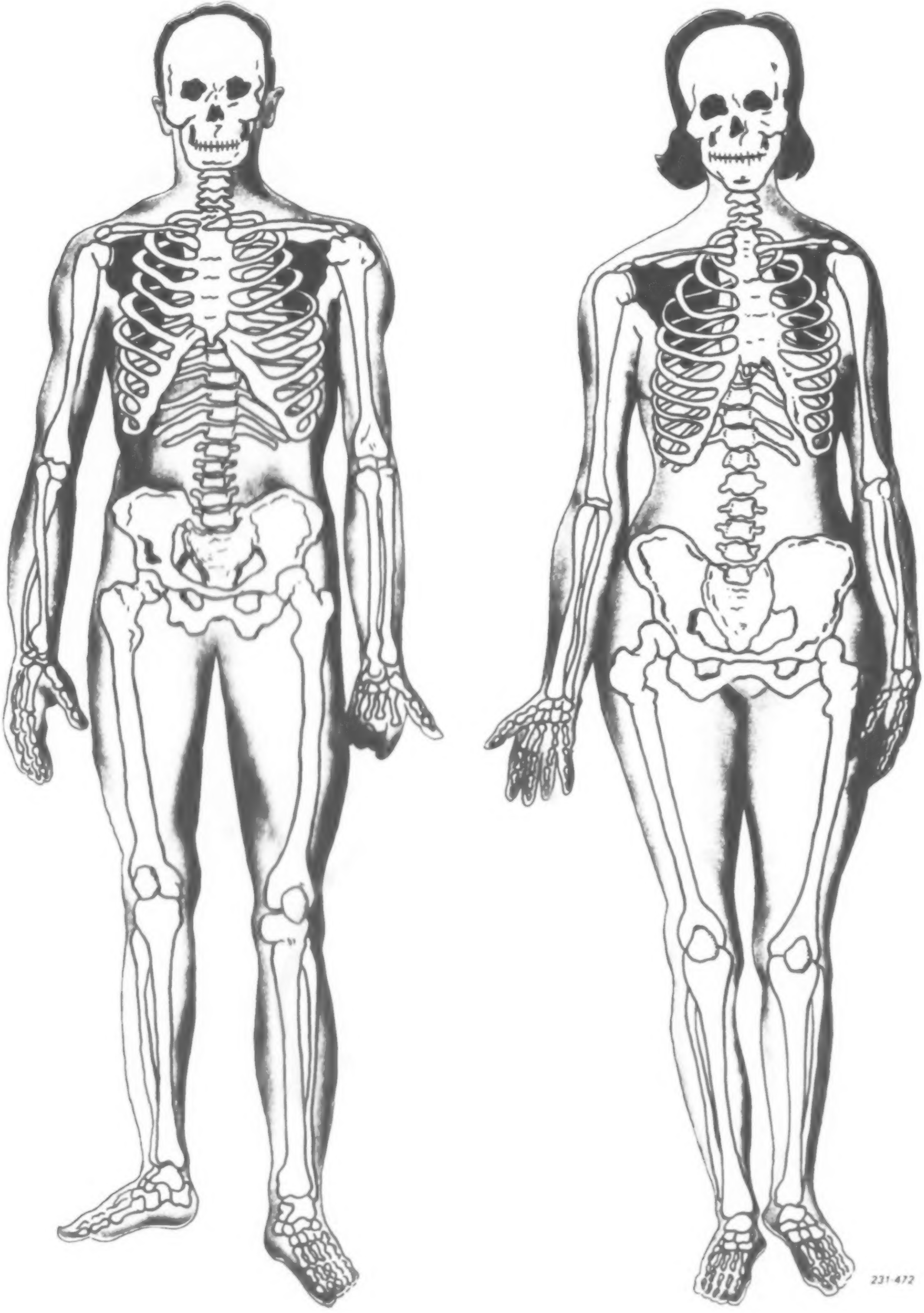

Figure 2-4. Skeletons.

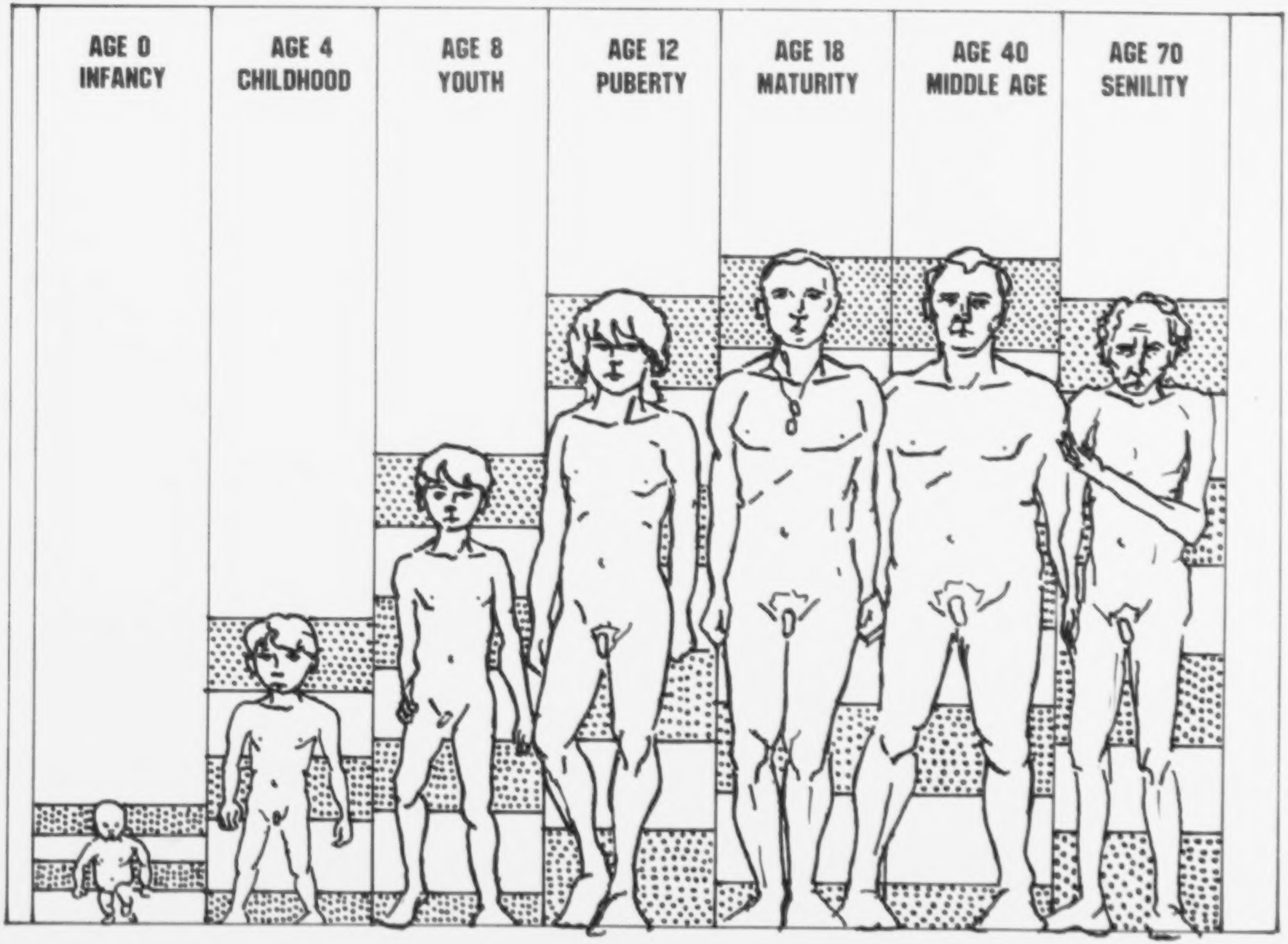
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Figure 2-5A. Proportion changes in the male figure.

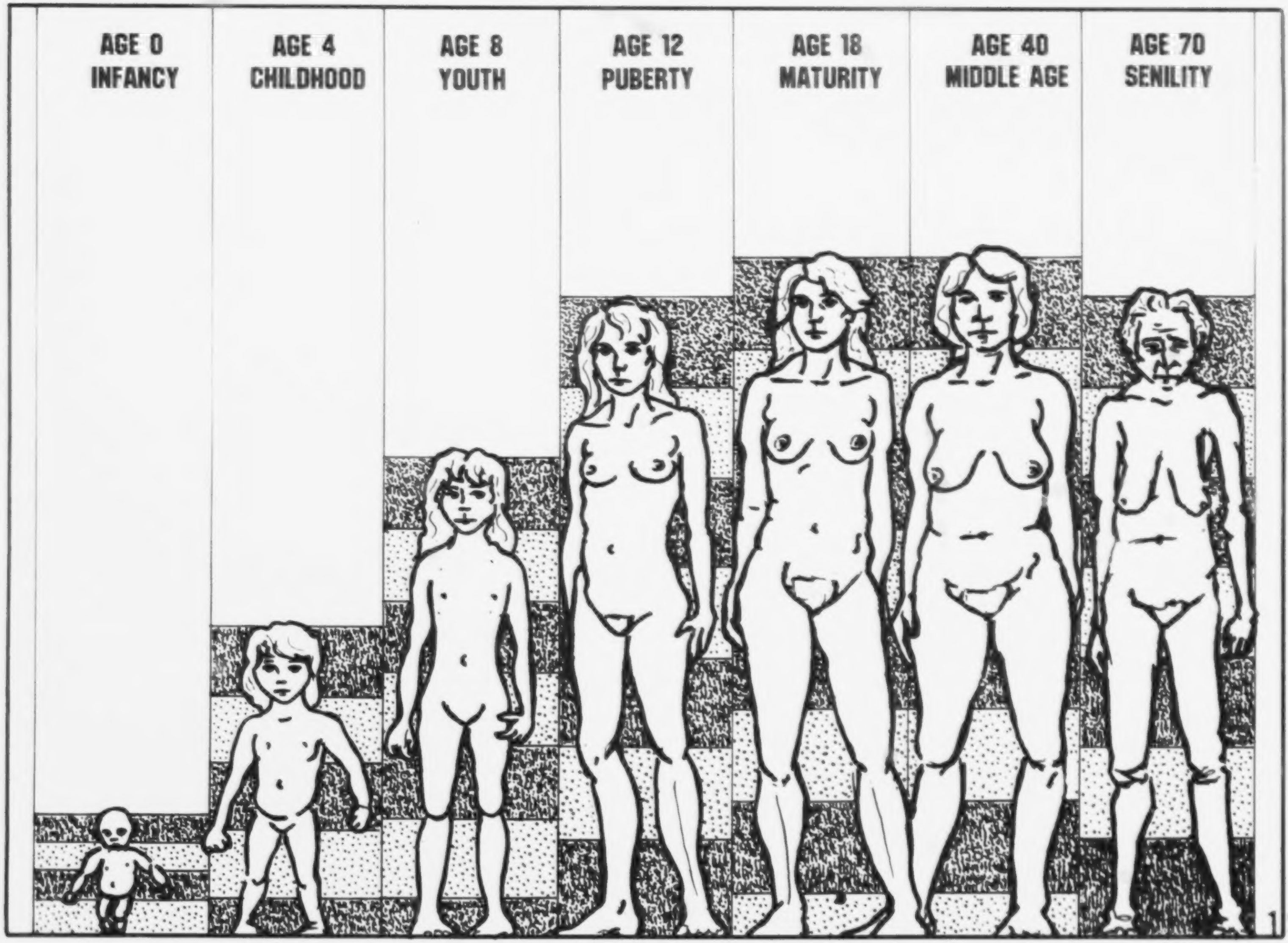
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Figure 2-5B. Proportion changes in the female figure.

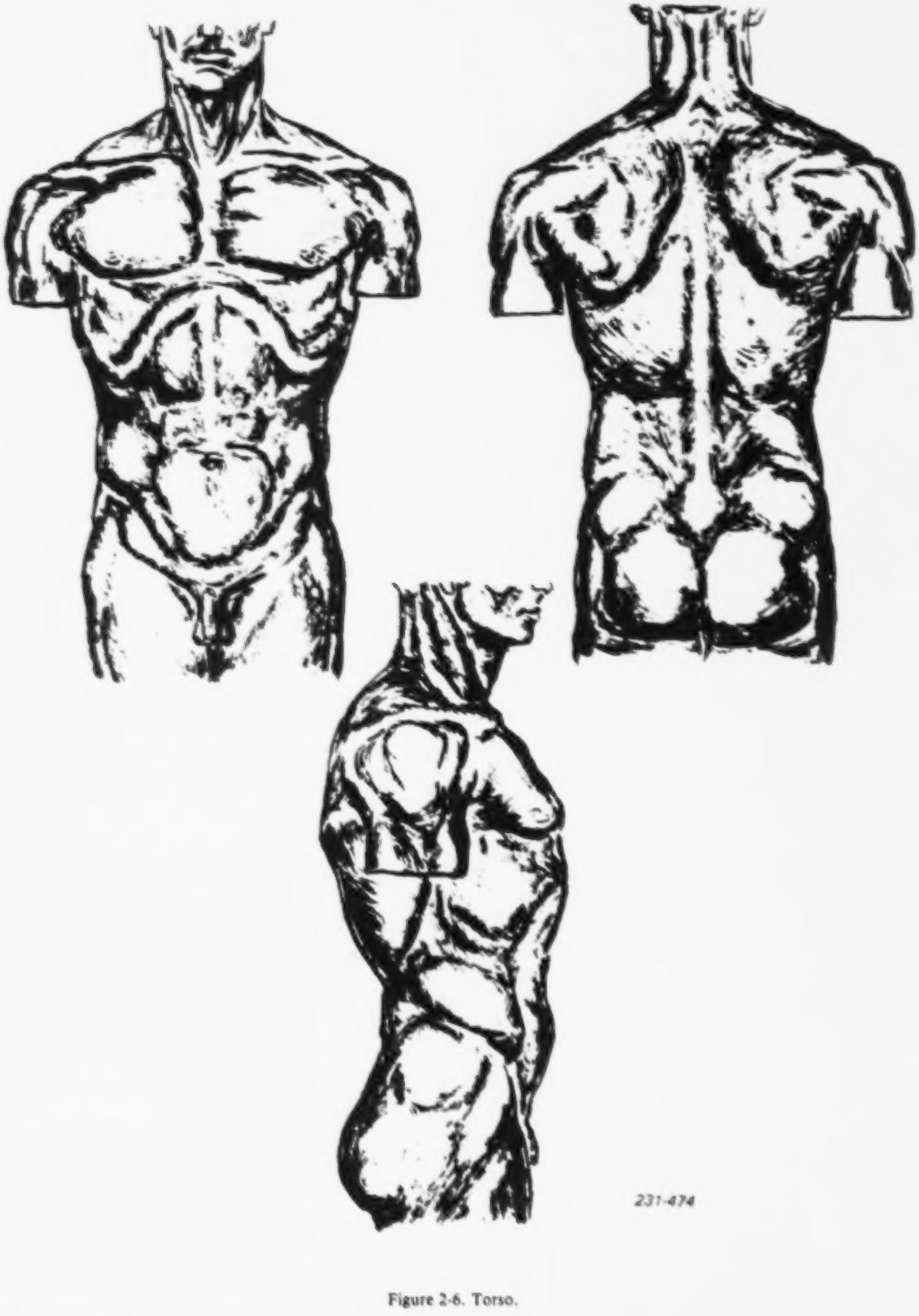

Figure 2-6. Torso.

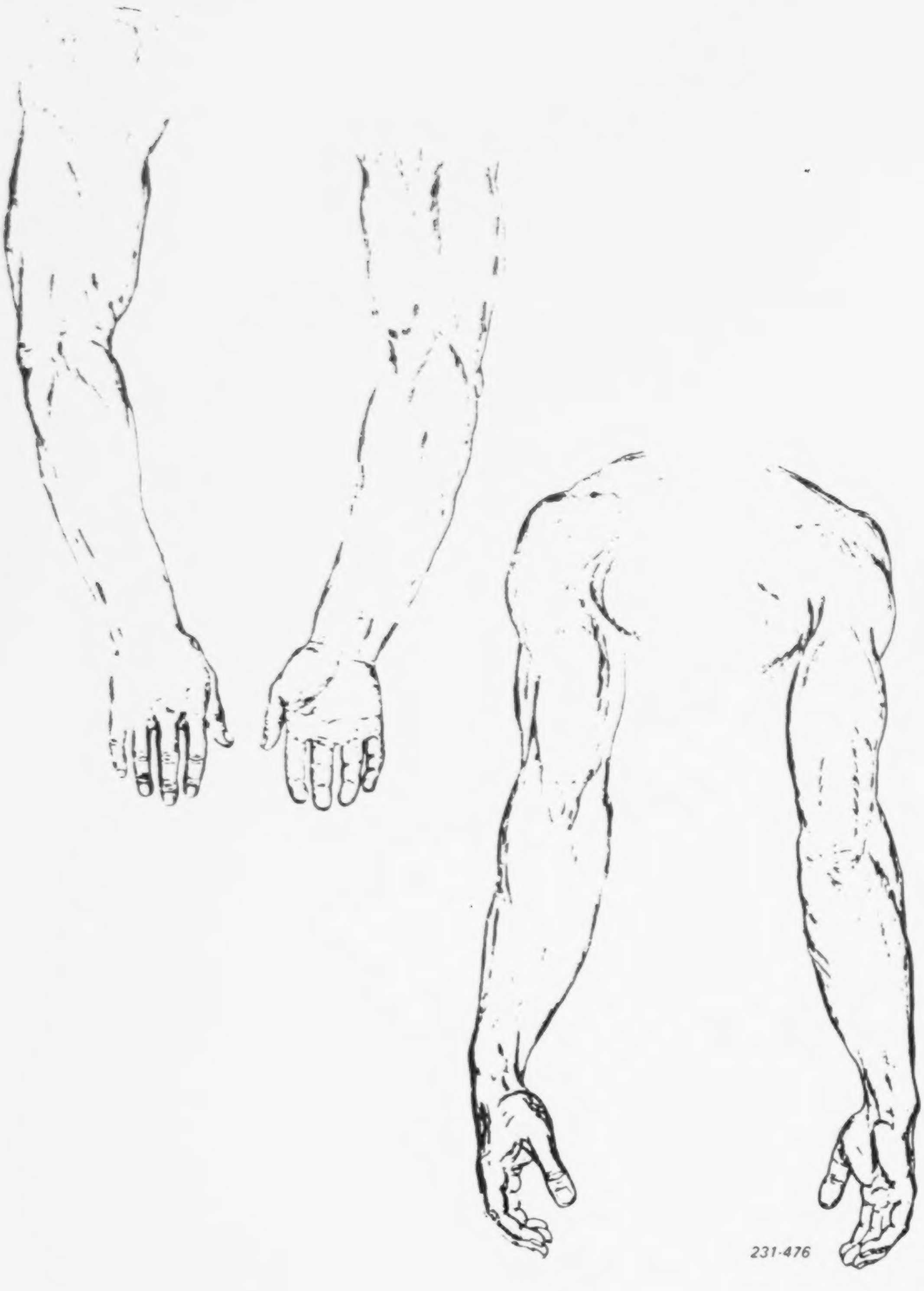

Figure 2-7. Arms.

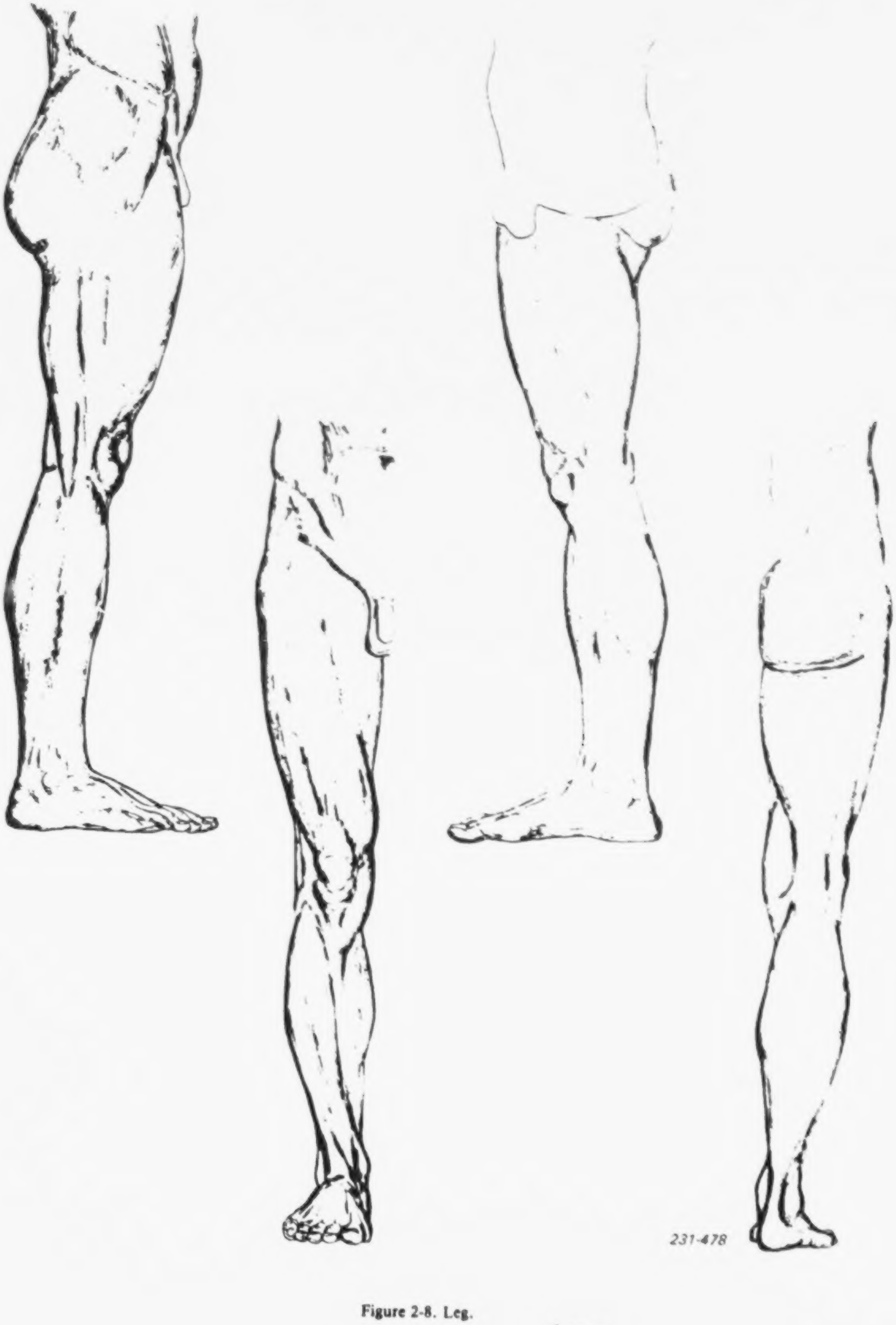

Figure 2-8. Leg.

Exercises (213):

1. What are the three masses of the torso?

2. What is the shape of the rib cage?

214. Specify how the function of the arms and legs affect their shape.

The Arms. The arm is based in the shoulder girdle. It has one bone in the upper arm (the humerus) and two in the lower arm (the ulna and the radius). The upper and lower arms are modified cylinders of approximately equal lengths as in figure 2-7. The mass of the shoulder descends as a wedge, sinking into the flattened outer arm halfway down. From the front, the arm wedges downward and enters the forearm just below the elbows. When the thumb is turned away from the body, the mass of the forearm is oval in shape, becoming round when the thumb is toward the body because the bones of the forearm cross. From the back, the mass of the shoulder enters the arm on the side; at the elbow, the arm and forearm arc as a hinge joint. (See foldout 5.)

The Leg. The lower limbs—the thigh and the leg—correspond to the arm and the forearm of the upper limb. The thigh extends from the pelvis to the knee, and the leg from the knee to the foot. The longest and strongest bone of the body is the femur or thigh bone (fig. 2-8). The column of the thigh and leg diminish in thickness as it descends to the ankle. From any view, it also has a reverse curve that extends its entire length. From either side, a wedge shape overlaps the rounded form of the thigh and this again overlaps the square form above and below the knee joint. The leg and the calf are triangular in shape and the ankle is a square. The femur (thigh bone) is balanced by the muscles that pass up the shaft of the thigh bone to the pelvis. The human body is provided with a system of levers and pulleys that cannot be matched by any machine for mobility and response. (See foldout 6.)

Exercises (214):

1. When the thumb is turned away from the body, what is the shape of the forearm?

2. What is the longest and strongest bone in the body?

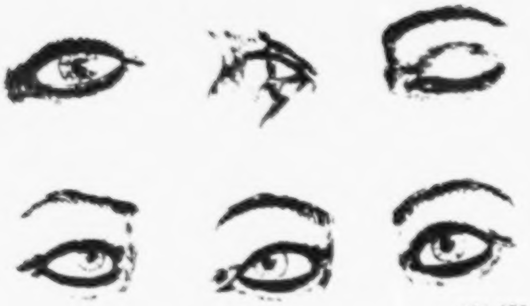

Figure 2-9. Eyes.

215. Describe the parts of the human head, and characterize how they are artistically related.

The Head. The head, like other parts of the body, is considered along with the neck as a unit. The division of the body is somewhat arbitrary because the neck is also considered part of the trunk or torso. Making arbitrary divisions is useless because no one part can logically be considered independent of its adjacent parts.

When drawing the head, a step-by-step demonstration gives you the fundamental method for blocking in and locating the features. The egg-like shape with some simple measurements to find the location of the features of the head will give you the basic foundation of knowledge for drawing heads in any position (foldout 7).

The Eye. The eyes are the most expressive and the most delicate features of the face and are well protected by nature. The eye is set deep in a bony recess in the face—the eye socket (fig. 2-9). The eye is protected by the frontal bone of the forehead from above and the cheekbone below. The inner side of the nose affords a great deal of protection to the eye, because of the protrusion of the nose itself. The eyeball is round in shape, with three parts exposed when the eye is open. One is a small dark center called the pupil, through which we see. Surrounding the pupil is a colored area called the iris, and around all of this is the white of the eye.

The two lids that are the outer covering for the eye are fringed with lashes that serve as shades and sensitive feelers to protect the eye. Notice that the inner and outer corners of the eye are different. The upper lid overlaps the lower lid at the outer corners. The exposed part of the eye is always moist. The moisture reflects light and causes a distinct highlight. The location of this highlight depends on the direction of the light. It is a very important factor in making your drawing appear lifelike.

The Nose. As shown in figure 2-10, the nose is narrow at the upper end and wider at its base. The upper part consists of bone and reaches halfway down. The lower part is cartilage. The wide, lower end of the nose is composed of two sides, the front and under surface.

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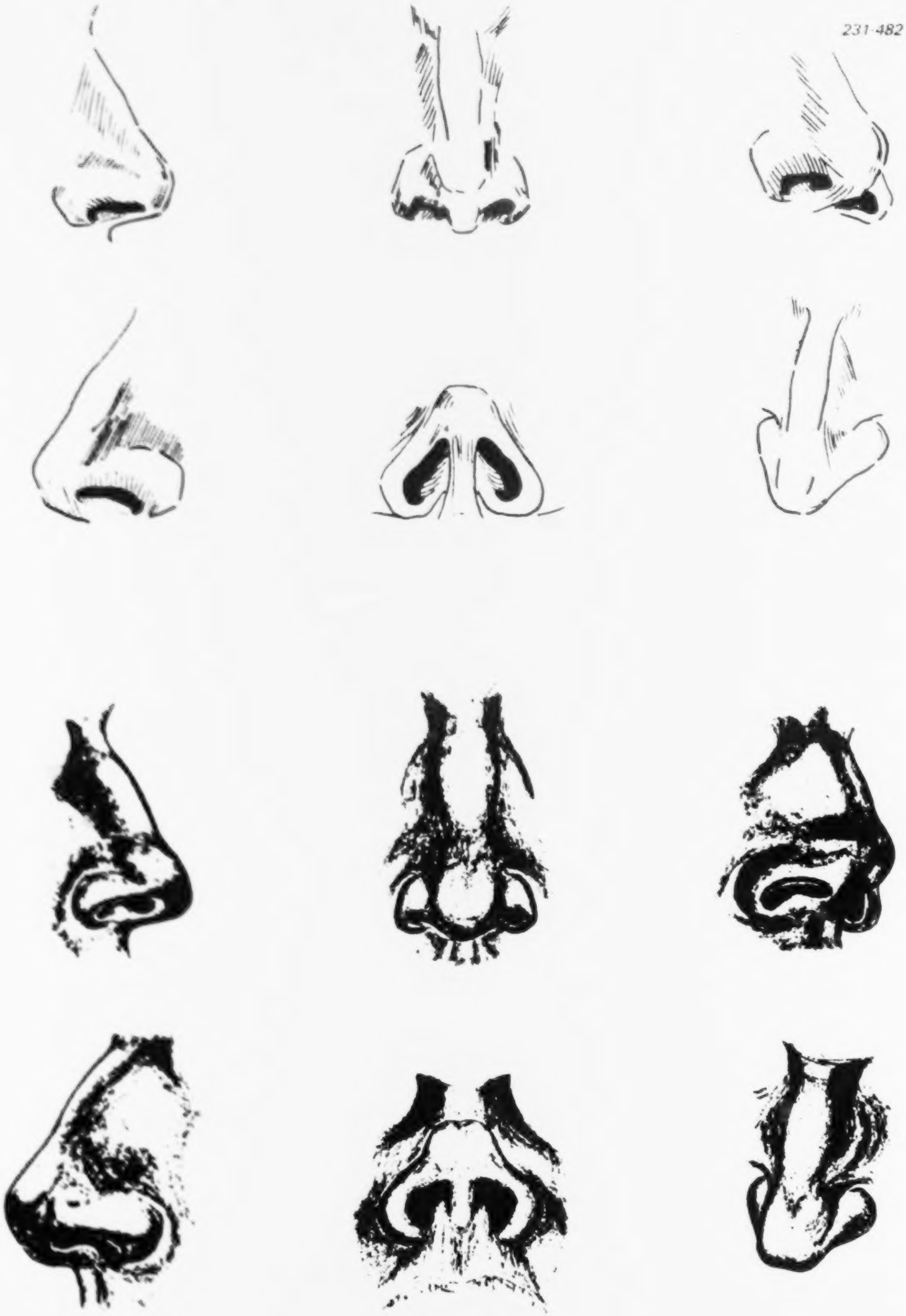

Figure 2-10. Nose.

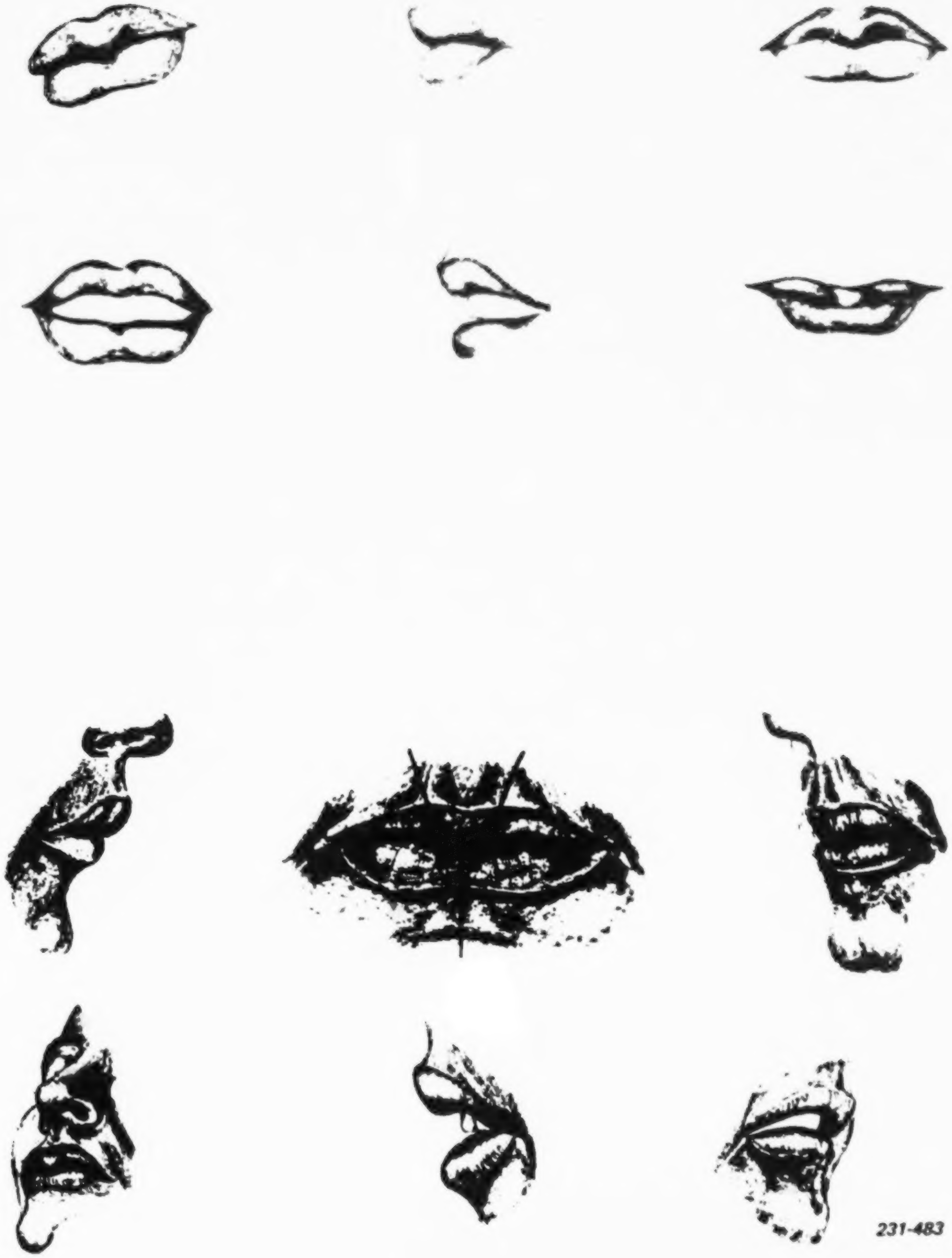

Figure 2-11. Mouth.

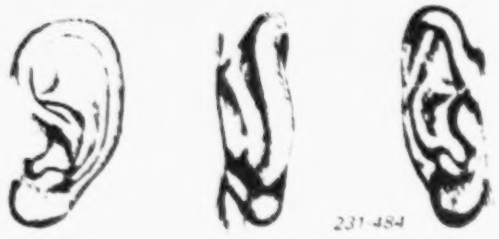

Figure 2-12. Ear.

The front plane leaves the root of the nose in a well-rounded form and widens as it forms the flattened bridge. The plane narrows as it descends, and again becomes round as it wedges between the bulbs forming the tip. This front surface continues down and under, and forms the small separation between the nostrils. The nostrils are inclosed by the wings, which form the lower sides of the nose. The wings also form the triangular shape that you can see when the head is tilted back. These wings and the end of the nose curl up into the nostrils in a rounded surface.

The Mouth. The mouth, like the eyes, is capable of much expression and movement. Of course, its shape depends to a large extent on the shape of the teeth; the rounder the teeth, the rounder the mouth. As you can see in figure 2-11, the upper lip is thickest in the center and thins with a downward curve to corners which are depressed. The forms in the upper lip are comparatively flat and angular; those of the lower lip are convex and rounded.

When the lips are seen in profile, their thickness, projection, and connection with the face are apparent. The upper lip projects beyond the lower lip which, in turn, projects beyond the chin. Consider the convex shape of the lips at the outer ends with extreme care when you draw the lips.

The Ears. The ears are formed of cartilage and have complex shapes, as shown in figure 2-12. Therefore, a good drawing of the ears can be made only after careful study. The length of the ears is the same as the nose and is about twice as much as the width. Notice that they slant downward and inward when viewed from the front, thus paralleling the sloping planes of the sides of the head. Notice how the contour of the inside edge of the ear spirals down into the depression above the canal. Other distinguishing features are the triangular form directly in front of the canal and the U-shaped space leading to the canal.

Exercises (215):

1. What part of the body is considered to be the most expressive?

2. Which feature of the face is located in the vertical center of the head?

3. Which two parts of the head are about the same length?

216. Specify how the functions of the hands and feet affect their shape.

The Hands. Other than the face, the hands are the most expressive parts of the human body. Therefore, give them careful attention when you draw them. You should be able to make excellent drawings of hands, using your own as models. Since there is very little flesh on the hand except on the palm side, you need to have a good knowledge of the bone structure to draw it well. Figure 2-13 shows the bone structure. Notice the proportions between the length of the individual bones. Notice also how bones of the fingers and of the thumb connect together; how the bones of the fingers connect to the bones of the hand; and how these bones and the bone of the thumb connect to bones in the wrist.

Observe in figure 2-13 that the palm without the fingers is nearly square, and that the fingers are about as long as the palm. When the fingers are extended, the hand is about three-quarters as long as the forearm, or is equal to the distance from the chin to the hairline. In drawing hands, be sure to draw them large enough.

Figures 2-14 and 2-15 show another important detail of hands. Notice in figure 2-14 that when the fingers are held closely together, as they are when lifting a heavy desk, the force is exerted in a straight line through the hand to the wrist. Thus, there is no tendency for the bones to twist as the fingers exert force. Notice in figure 2-14 that the lines of action shift toward the base of the thumb when the fingers and thumb are formed into a fist or used in any gripping action.

One of the important details in drawing hands is the placement of the folds (see fig. 2-15). Observe that the two folds of the finger come directly at the joints, and that there are two folds when the finger joins the hand. The first of these folds comes between the fleshy part of the finger and the palm; the other is created as the palm bends.

Figure 2-15 shows the back and palm side of the hand. Notice that the form of the back of the hand is basically convex, and that the form of the palm side of the hand is concave.

The Feet. The feet have about the same number of bones as the hands. However, the proportions are different, as you can see in figures 2-16 and 2-17. The feet are as long as one-half the distance from the knees to the bottom of the feet. Notice that the outside anklebone is slightly lower than the inside anklebone.

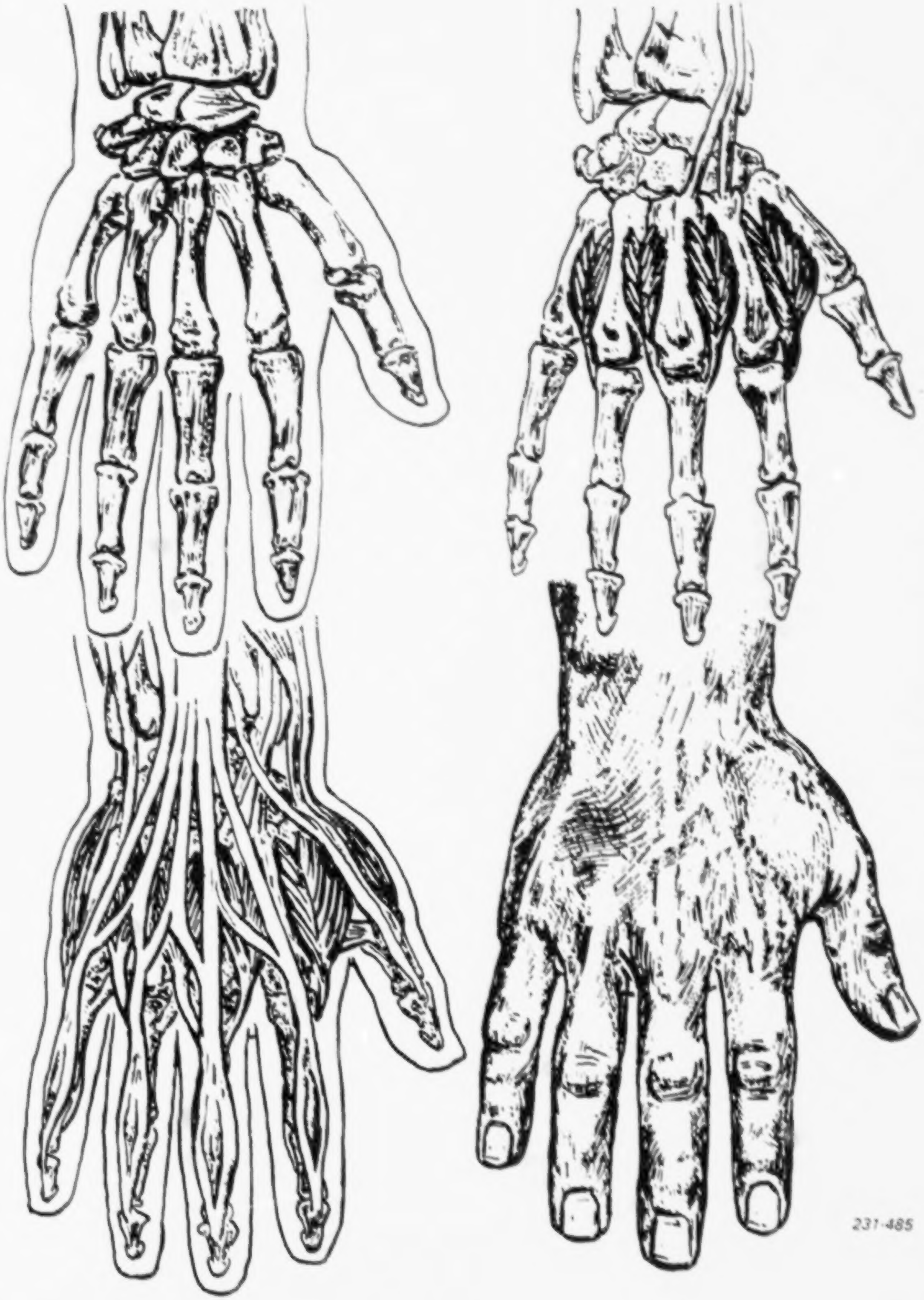

Figure 2-13. Hands.

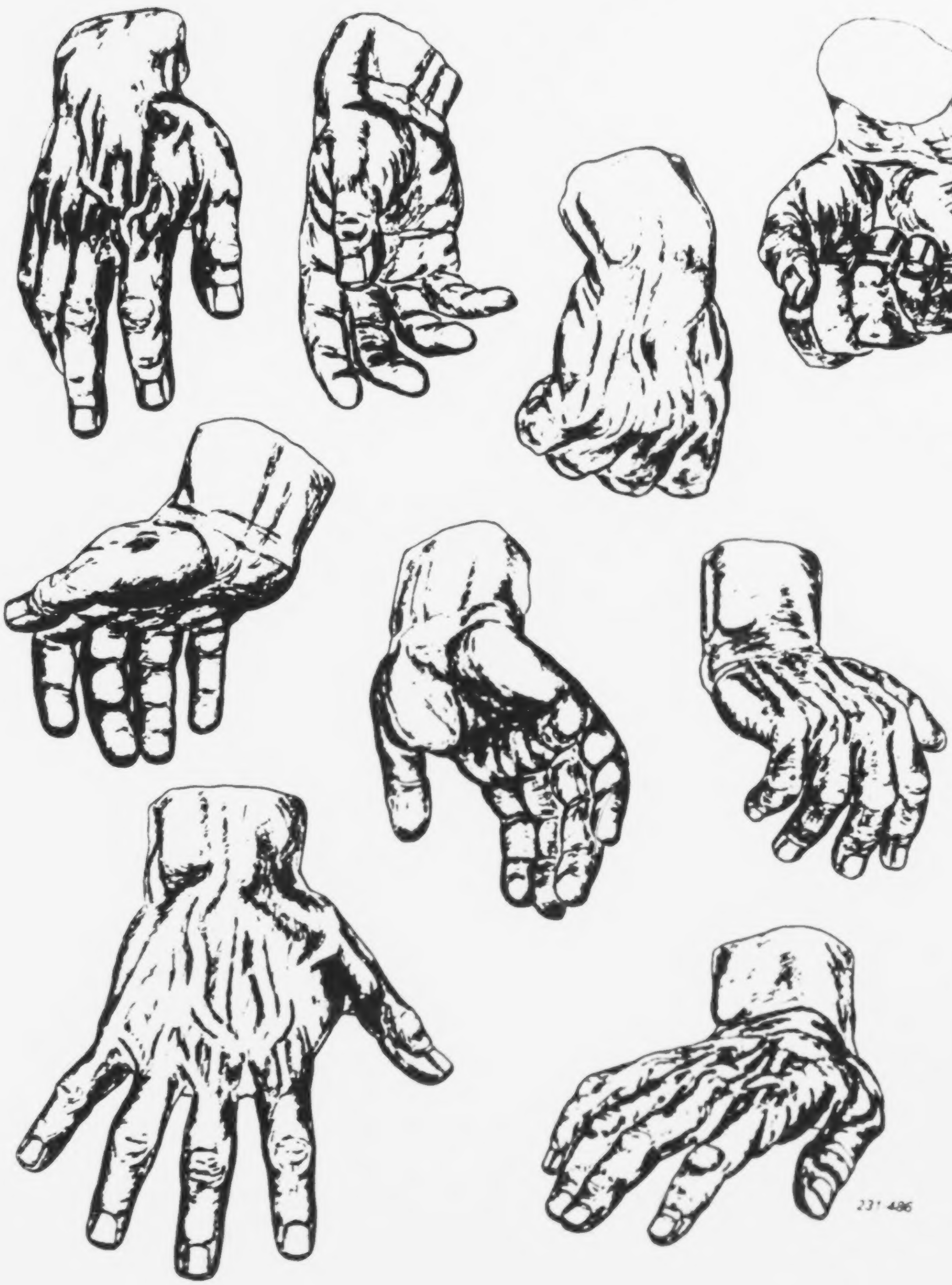

Figure 2-14. Hands.

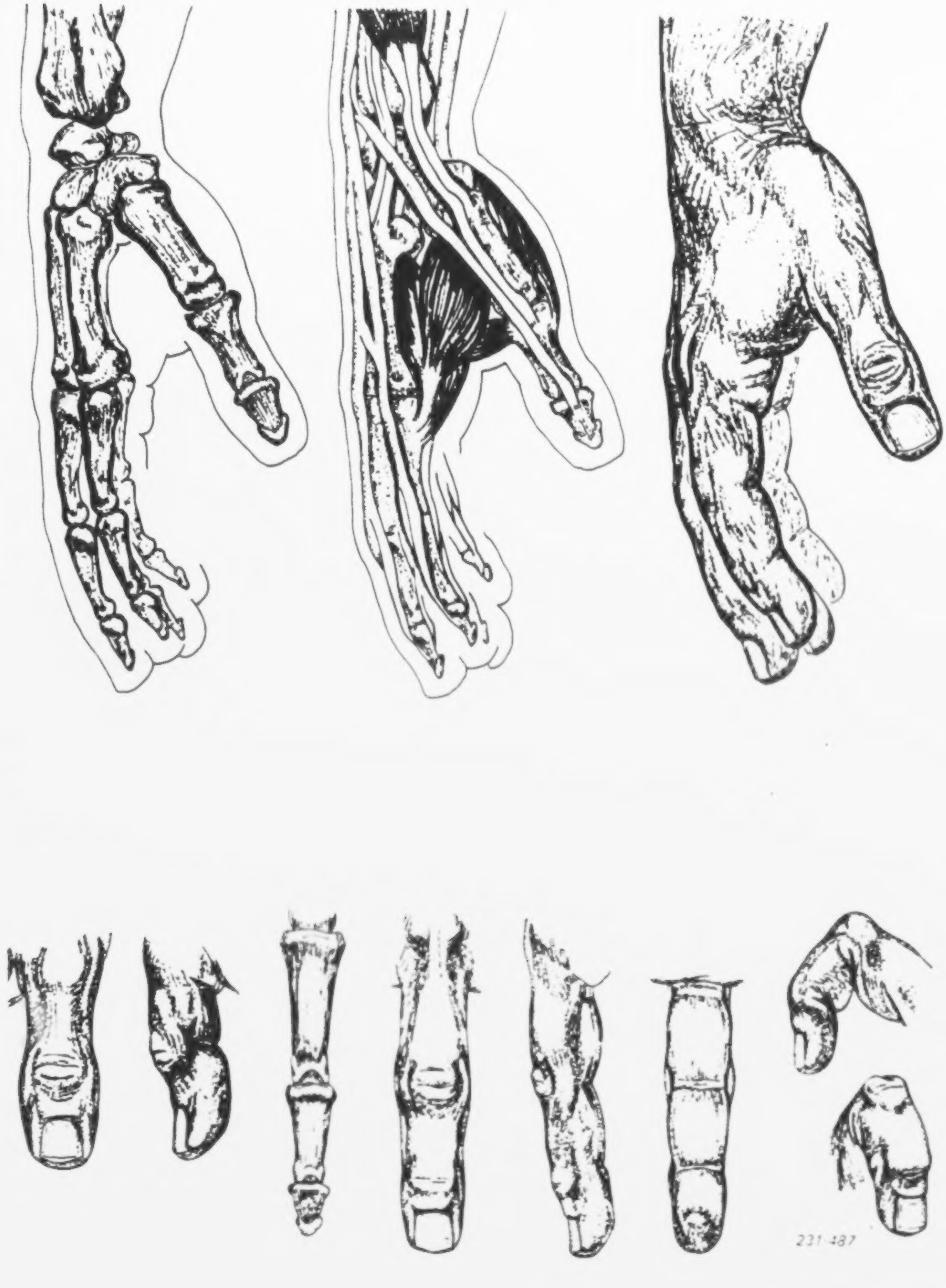

Figure 2-15. Hands.

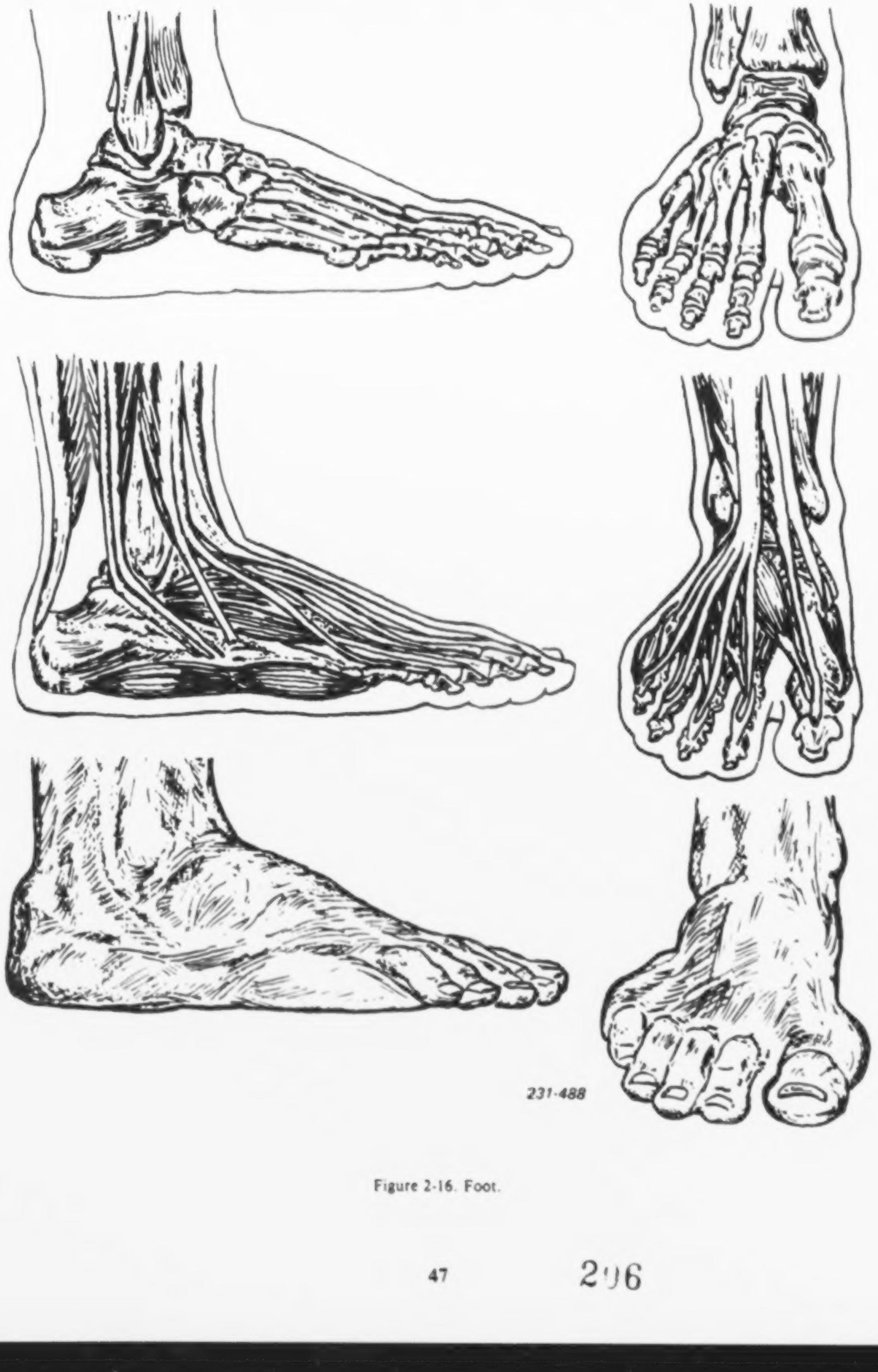

Figure 2-16. Foot.

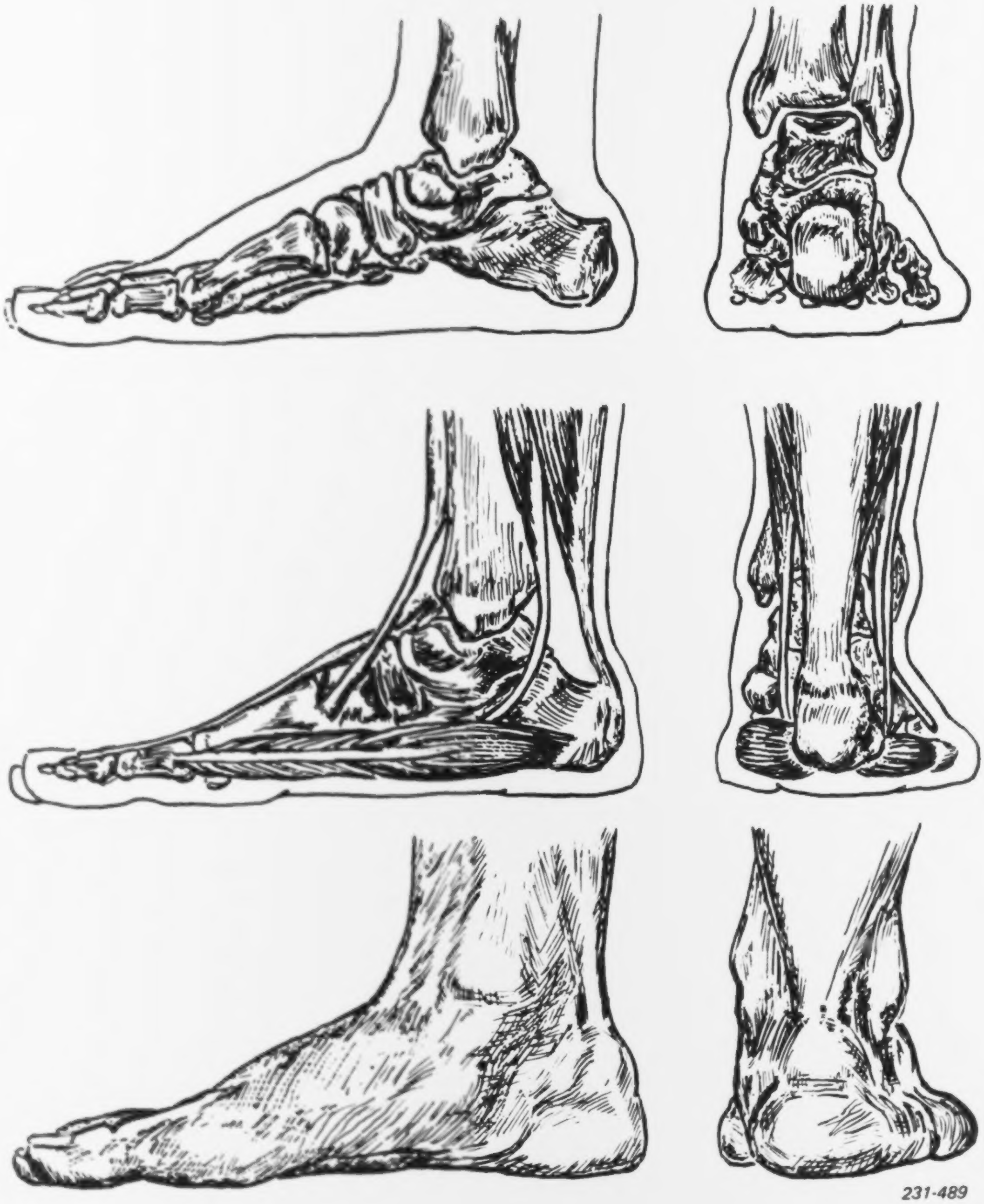

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Figure 2-17. Foot.

The high part of the foot is at the inside between the ankle and the big toe. As you can see, the foot slopes toward the toes and toward the outside edge.

The foot has very little movement. Most of its action is accomplished through the movement of the anklebones and between the joints of the toes and the foot.

Exercises (216):

1. Other than the face, what is the most expressive part of the body?

2. The important details that you should remember about the hands are:
   a. The basic shape of the palm is ____________ .
   b. The length of the fingers is approximately the same as the ____________________ .
   c. The length of the outstretched hand is equal to about three-quarters of the ____________ or the distance between the chin and the ____________ ____________ .
   d. The action of the fingers when outstretched is in line with the ____________________ .
   e. When the fingers are in a gripping action, the line of action shifts from the wrist to the base of the ____________________ .
   f. The form of the palm side of the hand is basically ______________ , and the back of the hand is basically ______________ .

2-3. Contour and Gesture Drawing

Now that you have the basic knowledge of proportion and the function of the human body, you are ready to learn how to draw the human body. Function and proportion, however, are not enough to adequately draw lifelike figures. You must also know about the contour and gesture of the figure. The following paragraphs and exercises will explain why contour and gesture drawings are necessary and how they are accomplished.

217. State the need for contour and gesture drawing.

Contour. In order to draw correctly, you must first be able to see correctly. Seeing an object is not enough; you must be able to "feel" the physical qualities of the subject. The ability to feel with your eyes does not come naturally. To develop this ability, you need to develop your powers of observation by making contour studies of your subjects.

A contour study is made by concentrating on the contour of the model or subject and drawing without looking at your paper. Sit closely to your model and focus your eyes on one specific point. Place your pencil on the paper (since this will be the only time that you will look at your paper, place your pencil in a large enough area to allow you to draw without moving off the edge of the paper). Without taking your eyes off the subject, wait until you are convinced that your pencil is touching the subject at the point where your eyes are focused. To start drawing, move your eyes slowly along the contour of the model. Follow the movement of your eyes with the pencil. Contour studies are slow work, so don't hurry.

The object of these exercises is to "feel" all the contours as your draw them (see fig. 2-18).

Don't worry about achieving a likeness; this will follow as you progress. These exercises are meant to help you develop your powers of observation. Practice is a must, so spend at least half an hour each day doing contour drawings. You will find that two 15-minute studies a day will be of tremendous help to your achievement in mastering the contour drawing.

Gesture. In contour drawing you study the structure of your subjects, but this alone is not enough. You also must study the action or expression of the subject. This study is called gesture drawing.

Gesture drawings record the action of the subject. These drawings dont necessarily look like the subject, but they record the performed action or expression of the subject. Gesture drawings are drawn quickly. As the model or subject assumes an action pose, place your pencil on the paper and, without looking at the paper, let your pencil wander quickly around the paper and record the action of your subject. See figure 2-19. Your eyes should see the whole subject and you should draw the whole subject at one time. You should not spend more than five minutes on any one gesture drawing.

For gesture drawings to be of any benefit to you adn your ability to draw, you must practice constantly. A few minutes spent doing gestures will loosen you up and help awaken your senses. Plan to spend about thirty minutes a day practicing gesture drawing.

Exercises (217):

1. Contour studies help you develop what ability?

2. When drawing a contour study, you must be convinced of what aspect before you start?

3. What are gesture drawings used for?

4. How should you see and draw a gesture drawing?

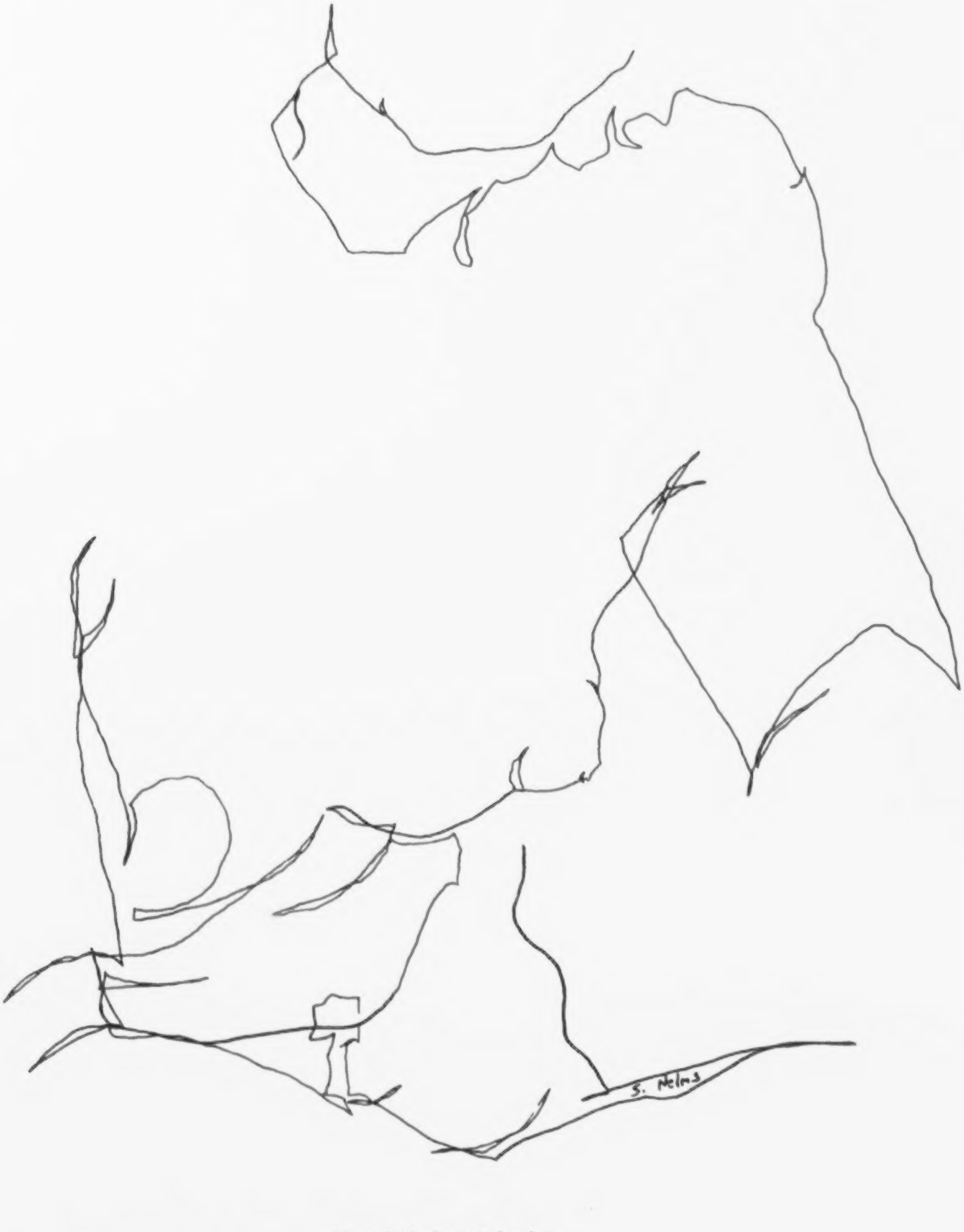

Figure 2-18. Contour drawing.

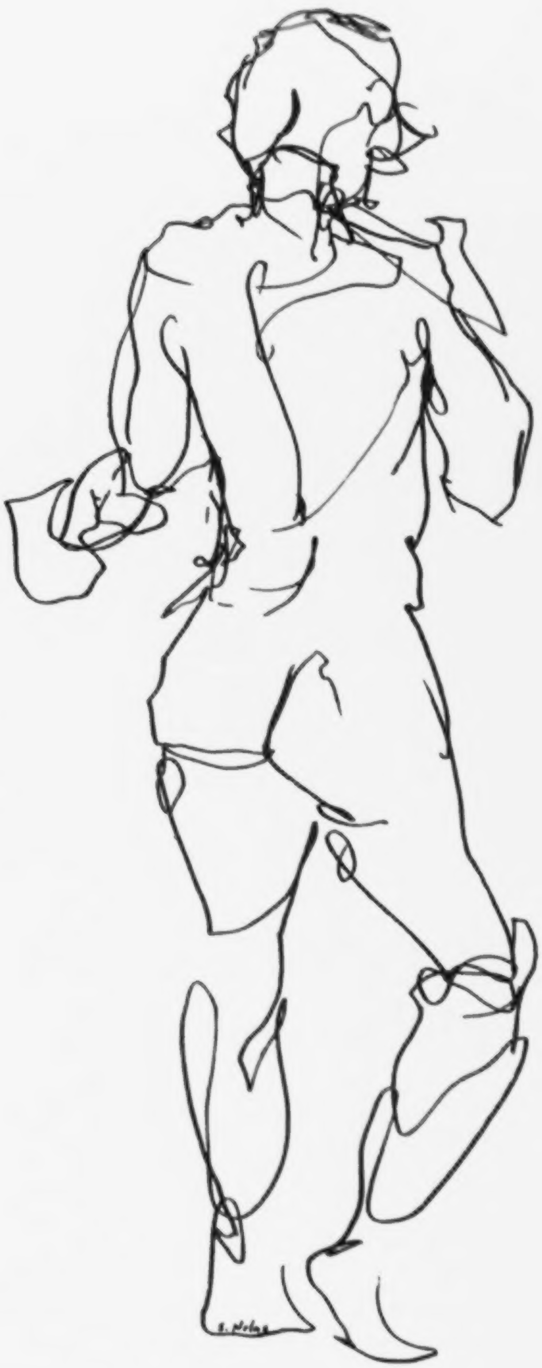

Figure 2-19. Gesture drawing.

2-4. Foreshortening, Shadows, and Reflections

There are three illusory effects in nature that the illustrator needs to be aware of to produce realistic and lifelike drawings. The three effects are foreshortening, placement of shadows, and reflections. Inept use of these effects can ruin a drawing. We will take a look at the fundamentals that govern the use of foreshortening, placement of shadows, and reflections.

218. Define foreshortening; and state the main consideration (in each case) when placing figures, drawing reflections, and drawing shadows.

Foreshortening. When working with compound forms, a graphics specialist must be conscious of an illusory effect called *foreshortening*. When an irregular (free) form appears to go toward or recede from the viewer, it is foreshortened. If in the irregular or "free" forms there are many curves, such as in the human figure, foreshortening is very difficult to create. A great deal of practice in drawing the human figure in a variety of different positions will give you experience in foreshortening. Also, the principles of measurement that apply to geometric forms can be used to great advantage in foreshortening the human figure. In figure 2-20, these principles have been applied in determining how much or how little is seen of the human figure, sitting on the floor with parts of the body toward the viewer. Notice particularly the lettered areas; the owercase letters designate foreshortening. In some unusual views, it is helpful to draw the figure in a cube or rectangular form that will quickly determine if and where a part of the human anatomy can be seen and in what approximate shape. Perspective can be the cure for many problems you may run into while drawing all types of forms. Remember to give careful consideration to the location of the station point so that distortion is minimized.

Placement of human figure. As with foreshortening, the correct placement of the figure in a perspective drawing is difficult, but important. The viewer of any picture automatically relates the proportions, scale, and size of all forms to the figure in the picture. Too, the viewer assumes that all adult persons are approximately the same height—somewhere between 5 feet and 7 feet.

Proper use of the vanishing point is the main consideration in correctly placing the figure. Use the vertical distance between the receding guidelines to the vanishing point to establish the height of any figure anywhere in the picture (as in fig. 2-21). To place the figure to the left or to the right of these guidelines, extend horizontal lines from the head and feet off the vanishing point lines as shown in figure 2-21. Once the height is determined for one figure, the others are automatically taken from the intersection of the two horizontal lines and the receding lines going to the vanishing point.

Reflections. Another aspect related to compound forms is reflection. An object reflects as far below a reflecting surface line as it projects above the reflecting surface. The reflection is not a meer reversal of the scene being reflected. Although the eye level remains

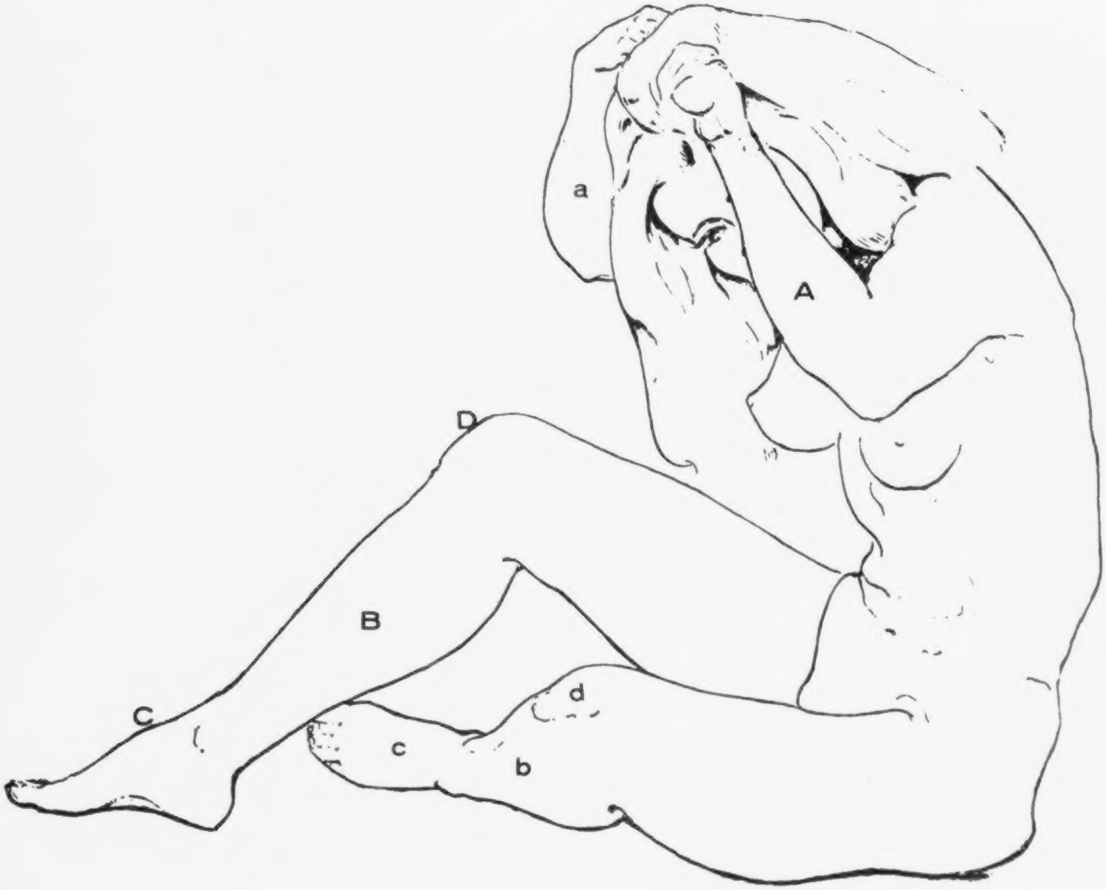

Figure 2-20. Foreshortening.

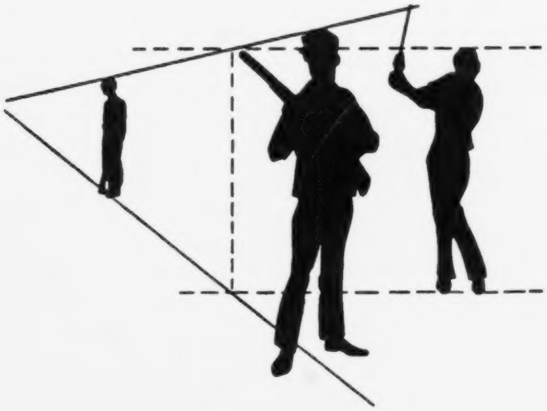

Figure 2-21. Background figure placement.

constant, the view is a reflected one. When the eye is above an object, you are looking down at the object; and since the object is reversed in a reflection, the proportions remain the same; but you are now looking up at the object. See figure 2-22. When the object being reflected is close to the eye level, the reflection is nearly a duplicate in reverse, but not so when the object is well below the level of the eye. Eye level is the main consideration.

Shadows. Light travels only in straight lines. From an established light source, lines are drawn to touch the corners of the form and are continued until these lines touch the surface of the plane on which the object rests. All shadows recede to the same vanishing point when there is a single source of light. The shadow's vanishing point will fall on the horizon line directly below the source of light. Shadows follow the contour of the plane upon which they fall, as shown in figure 2-23. The main consideration when drawing shadows is light source.

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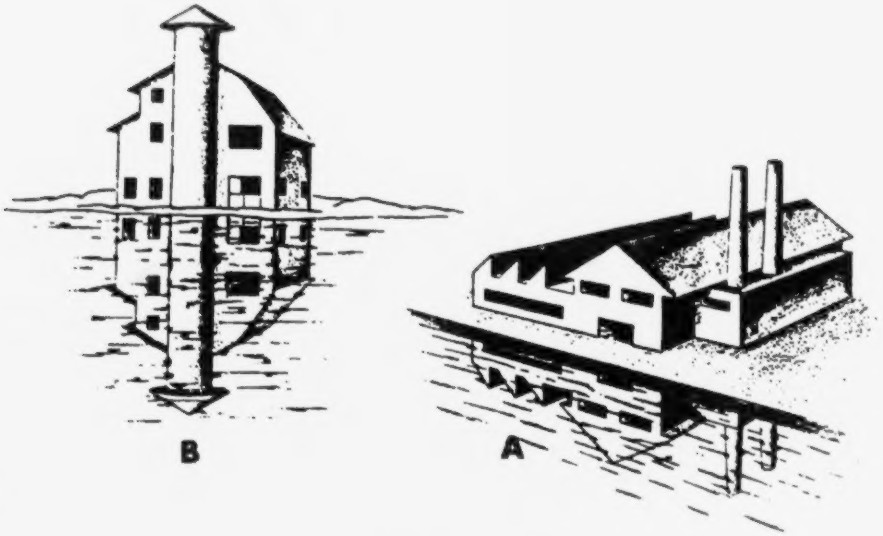


Figure 2-22. Reflections.

Exercises (218):

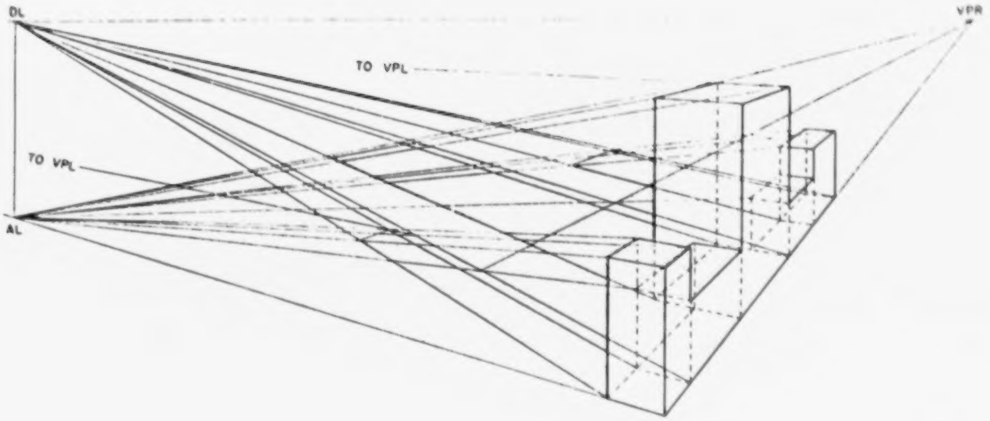
1. What is foreshortening?

2. What is the main consideration when:

   a. Placing figures?

   b. Drawing reflections?

   c. Drawing shadows?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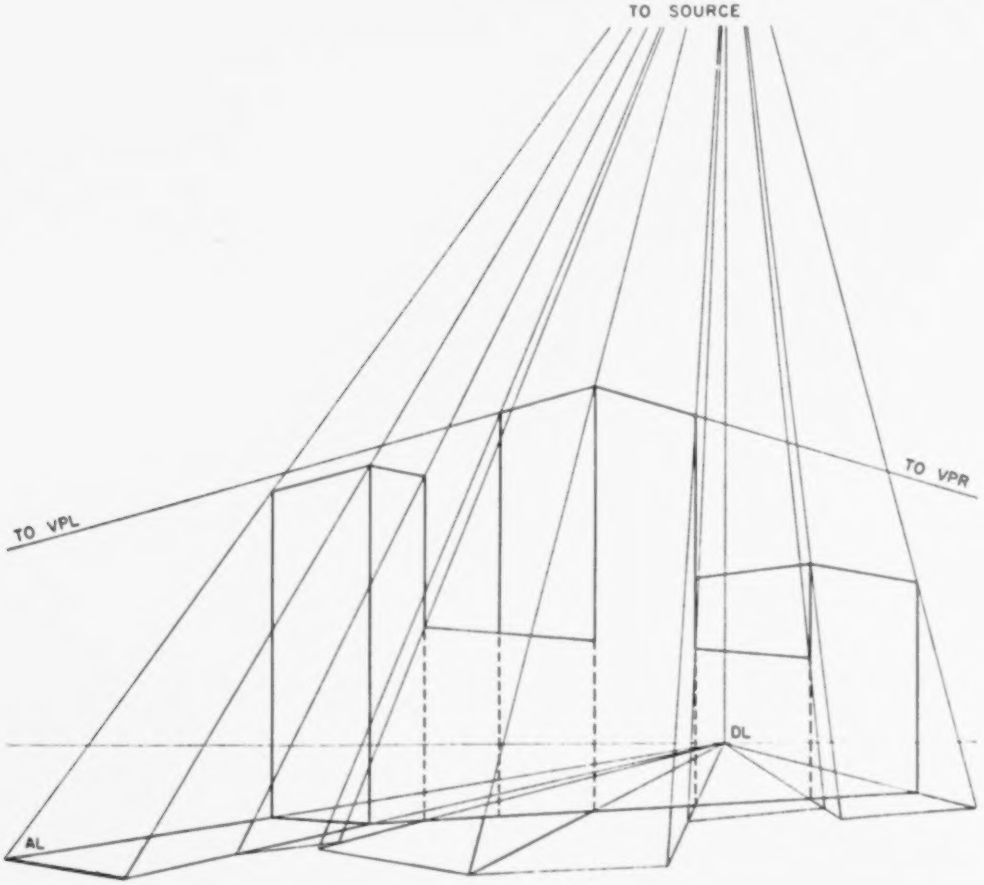
VPR
TO VPL
TO VPL
AL

Ground shadow, looking away from light.


TO SOURCE
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AL

Ground shadow, looking toward light.

Figure 2-23. Shadows.

CHAPTER 3

Cartoons and Caricatures

THE ABILITY TO cartoon and draw caricatures is a specialized field for most commercial artists. To become a good cartoonist, every student should begin his studies with a reasonable amount of self-confidence. Since the same knowledges that apply to figure drawing apply as well to cartooning and caricatures, a good artist may find that all he lacks to become a cartoonist is self-confidence.

3-1. Cartoon Definition

The popular definition of a cartoon is a humorous drawing but there are no formal boundaries to the style of drawing called cartoons. Cartoons range from realistic illustrations to totally abstract design. All of the basic aspects of cartooning and caricatures can be summed up in one basic principle—behavability. Cartoons are simplified exaggerated forms that show expressions.

219. Specify how expressions and exaggerations are used to effect a cartoon.

Expressions and Exaggerations. Expression is action. For example, all jumping figures have both feet off the ground, but all walking figures have both feet touching the ground. You make visual studies of real people and convert their movement and expressions into humorous drawings. A cartoon differs from the more-serious-type drawing in that it is usually drawn with a much looser treatment. That is, you concentrate on the action and attitude of the figure more than you do on the fine detail. Then, too, cartoons are usually simple line drawings, requiring substantially less variation in mediums than used in other types of art work.

Facial Expressions. In cartooning, the features of the face are usually drawn as simple, geometric shapes. As you can see in figure 3-1, the eyes can be drawn as circles, ellipses, dots, or lines. Humorous effects in the face are produced by exaggerating or distorting the average measurements and relative proportions within facial features. When the caricature of a person's face is being drawn, all the irregular characteristics should be observed and exaggerated.

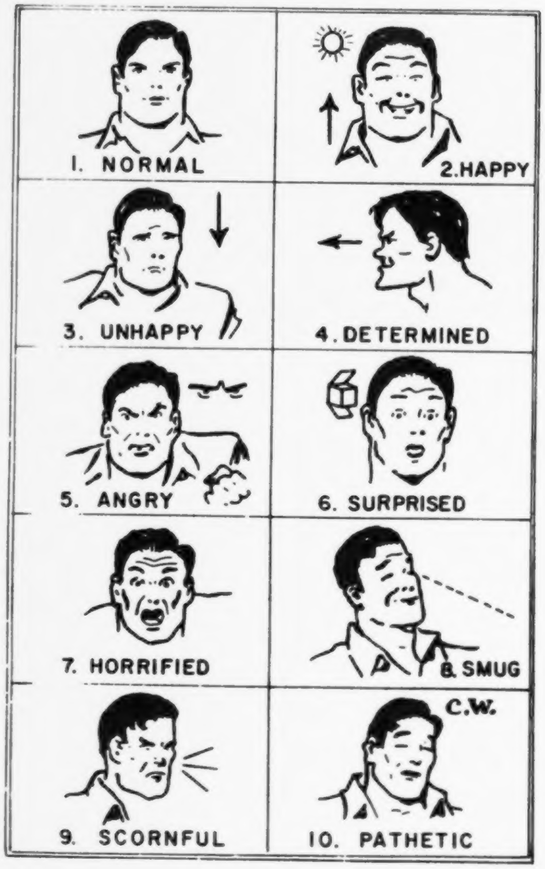

Figure 3-1. Cartoon eyes.

The one set of rules generally accepted by all cartoonists is that facial expressions are produced by the movement or lack of movement of the eys, mouth, nose, and forehead. Figure 3-2 shows some examples of emotional expressions produced simply by changing the shape or position of those facial parts.

When the face assumes a happy expression, the parts of the face are lifted. The corners of the mouth are pulled up and out. The cheek muscles are bunched by this action so that the lower lid of the eye is pushed up and almost closed.

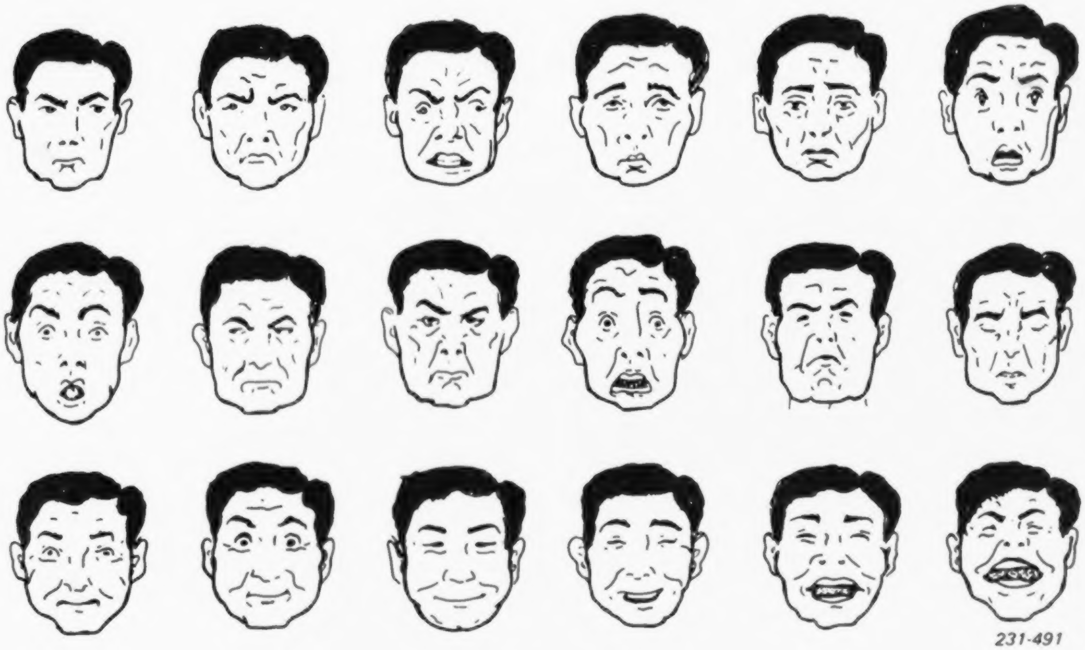

Figure 3-2. Facial expressions.

An unhappy face is just the opposite, the corners of the mouth are dropped, the eye and eyebrows are lowered, and the forehead wrinkled, whereas, determination is expressed by the lowering of the brow and the jutting out of the lower lip and chin. Other emotions such as anger, surprise, horror, smugness, and scorn can be expressed by similar facial movements. Along with the facial expressions, body movements should fit the emotional appearance of the face.

Exaggeration. Exaggeration is the one exception in cartooning where the cartoonist must use a little discretion. Although the rules of expression and exaggeration are generally accepted, exaggeration can be cruel. So let it be reemphasized that as a cartoonist, you are bound by no rule except that of GOOD TASTE.

Exercises (219):

1. What is a cartoon?

2. Expression is created by both the ____________ and the ______________________ .

3-2. Captions

Ordinarily, there are two types of cartoons. Those that are pantomime—all action and telling the story in picture—and the captions or punchline type. In many instances, it is the punchline, gag, or joke that inspires the cartoonist to draw. Keep punchlines as short as possible and let the action of the drawing do the work.

220. State the procedures for creating cartoon characters and caricatures.

Character Creation. The number of different characters a cartoonist can draw is limited only by his imagination. Because the face controls the mood and emotional expression, it is the important part of a cartoon character. The head can be any basic shape, and this shape can be used to create many other characters. Characters are created by adding or making changes in the facial structure as shown in figure 3-3. As shown in figure 3-4, one character can be many different characters by making very minor changes. When a cartoon character is required, one should consider the end use.

When cartooning, you may not always be called upon to cartoon or caricaturize the human being. Some jobs call for animals, aircraft, ships, pieces of machinery, vehicles, or any inanimate object with human characteristics. Figures 3-5 and 3-6 are examples of this type of cartoon.

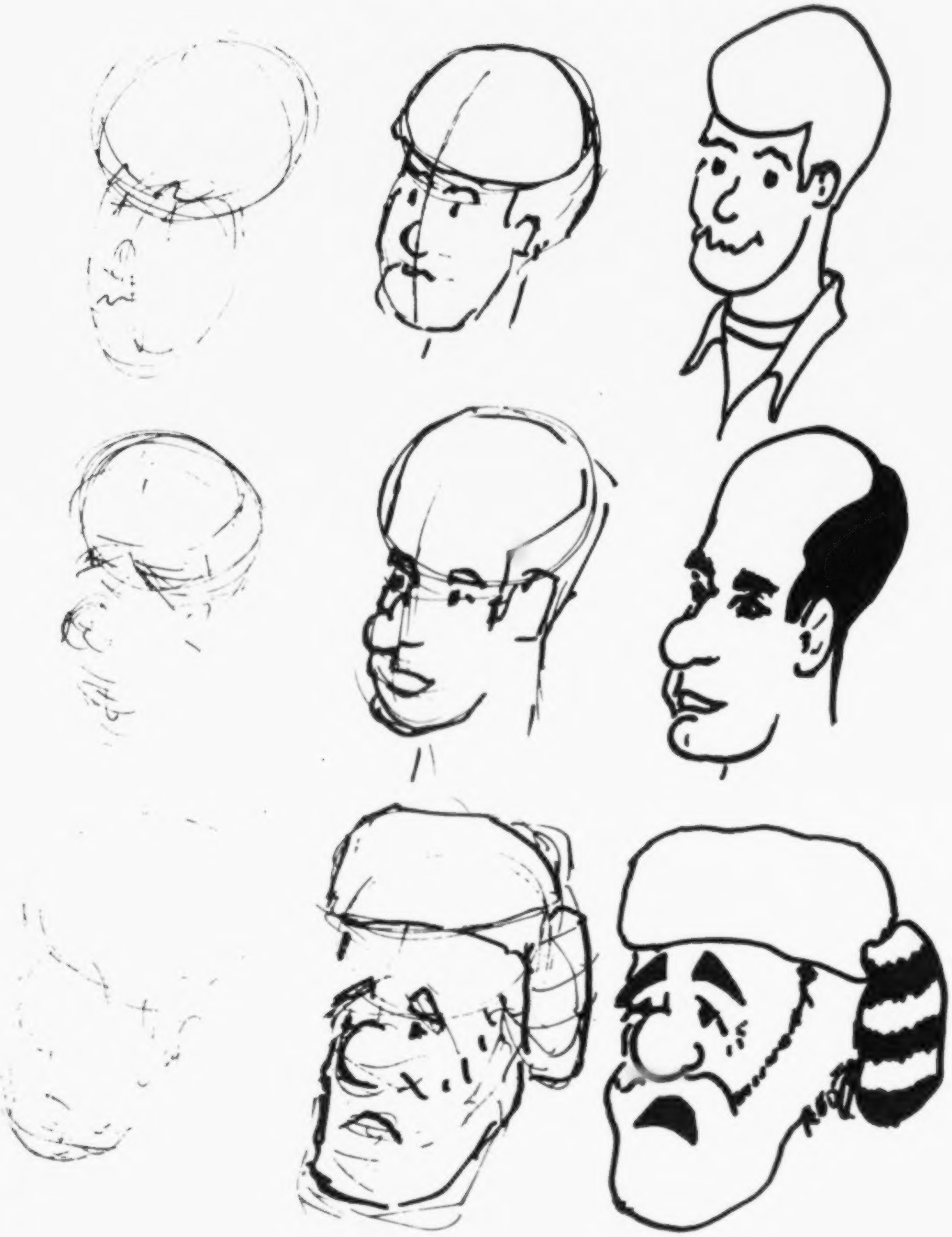

Figure 3-3. Changes in facial structure.

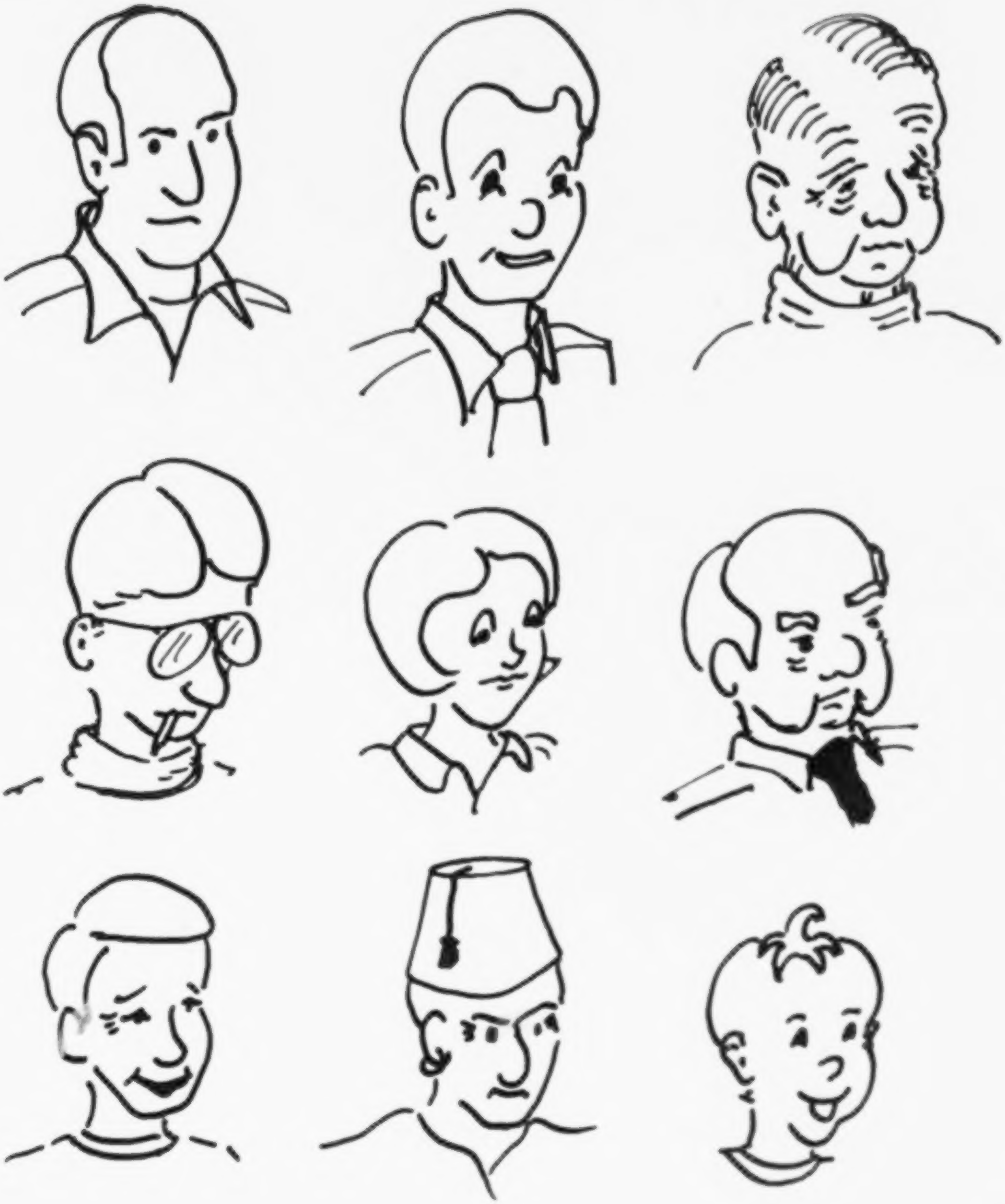

Figure 3-4. Changes in facial structure.

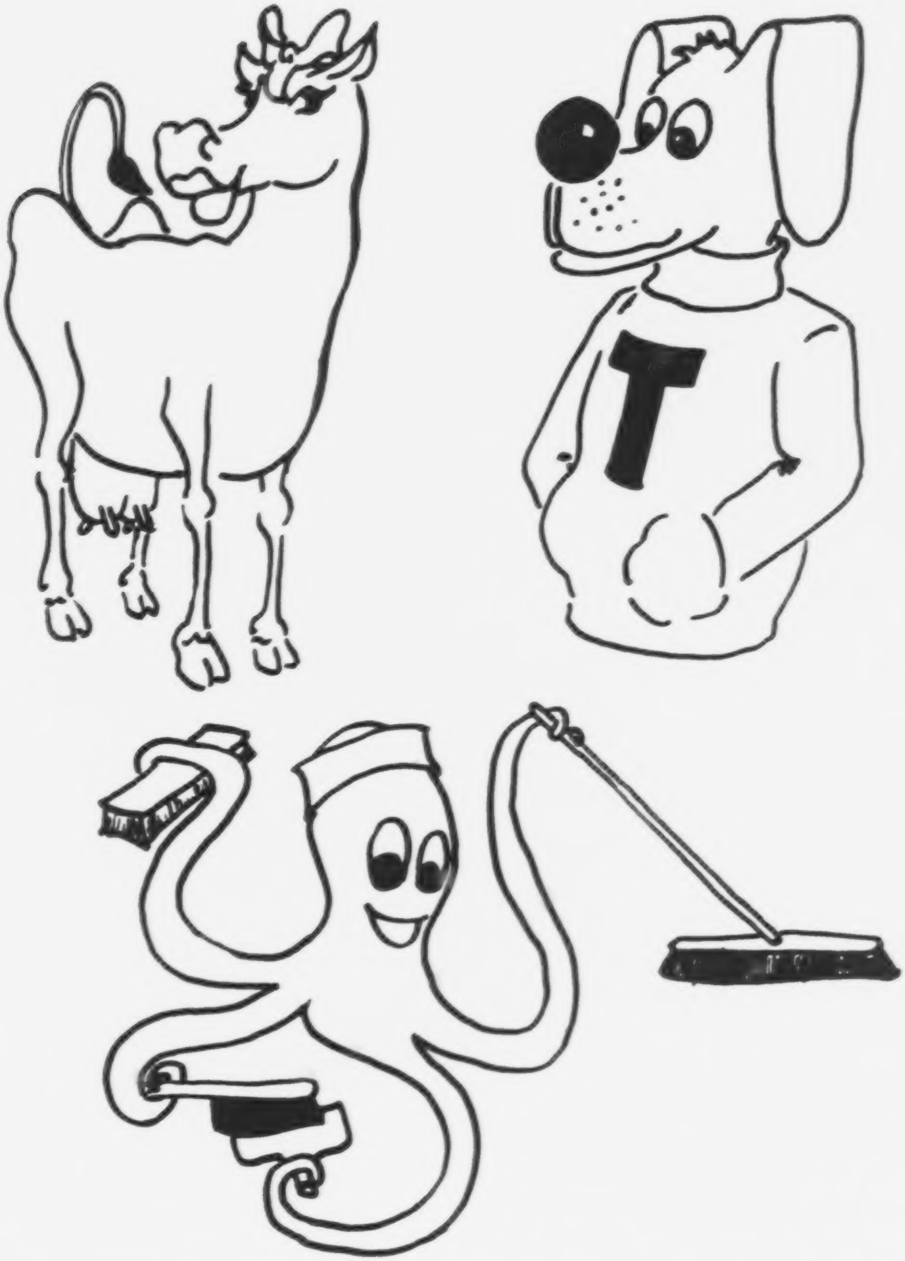

Figure 3-5. Animals with human characteristics.

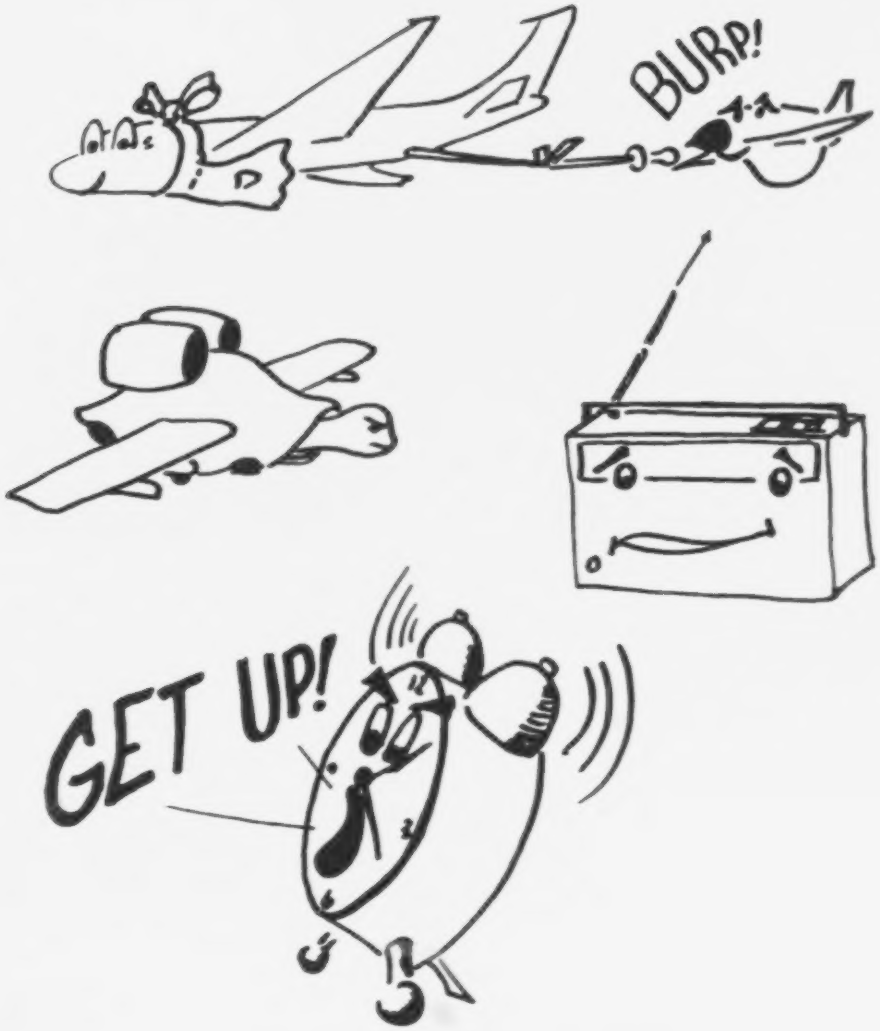

Figure 3-6. Machinery with human characteristics.

When creating a cartoon character, it is best to use the physical features and dress that have become popularly identified with certain types of people and with people from certain areas. These symbolic features have been associated with certain types of people for so long that the public instinctively relates a certain appearance to a particular type of person; for example, the hillbilly right of the hills. His symbolic attire is a torn, checkered flannel shirt, bib-type overall with patches, a rumpled wide-brimmed hat; he is also usually in need of a haircut and shave. He is often shoeless and carries a long-barreled squirrel gun.

You should, when possible, use the established public impression that is readily accepted for a particular type of person. There is a symbolic type for nearly every type and for every geographical area in existence, including foreign nations. The list is unending; and the following illustrations show but a few of the long, long list of possibilities.

You must experiment in cartooning just as in all phases of illustrating in order to find just the right design, the right nose or mouth, type of eyes or hairstyle, to fit the character so that he will blend into the situation properly. You will find that cartooning is more than mere doodling; it takes practice, experimentation, more practice, and a firm determination to become a good cartoonist. The cartoons shown in this chapter are the writer's creations—his style of drawing. Although it is proper for you to copy them for practice, it is essential for you to develop your own style of cartooning before you can consider yourself a cartoonist of any caliber. Remember, it is your style; develop it to fit your abilities and needs.

Remember, it has already been said that not everybody will like your cartoons. What will fracture one group's funny bone may bring screams of protest from another. Solution: always know your audience.

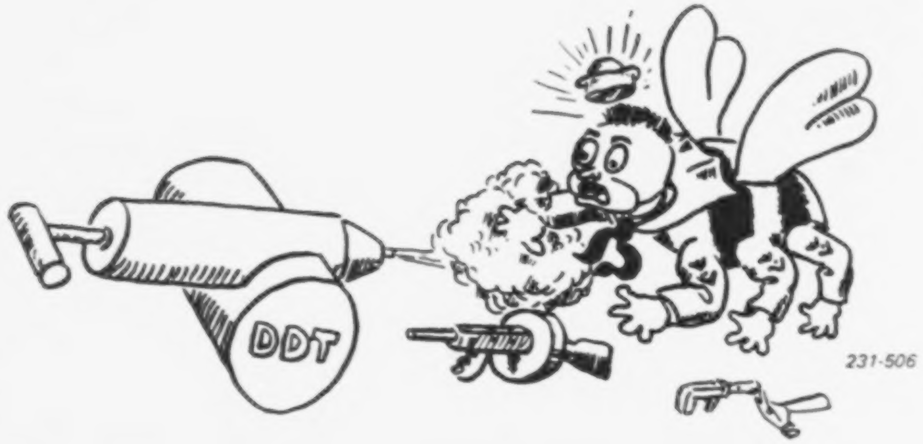

Figure 3-7. Bee of Seabees.

The different people of the world have many different characteristics and costumes and it is most intersting to work up several different interpretations of each of them, as you have been shown by a few examples.

When you are drawing a cartoon depicting a certain nationality, race, or period of history, it is extremely important to use the correct costume on the character. This aids in his identification and correctness, and when done well, adds to the humor of the character. In any cartoon, not only must the costume be correct for the character, but any supporting characters, and the stage or background if there is one, all must be in place with the main theme. The pattern must be consistent with all particulars related. In cartoons, the background is usually greatly simplified and reduced to just those elements essential to clarify the picture. In some cartoons, there is no background at all; other times, the background may be highly detailed. This again is usually a choice of the cartoonist. The use of background is usually determined by the style of the cartoonist. Most frequently, a cartoonist will use no more background than is needed to identify his character to a specific area or location.

You can also use cartoons effectively to make good-natured fun of someone or some group. This points out again that taking any situation, person, or group, you can create an effective cartoon out of it. For example, figure 3-7 is a cartoon prepared by a DM, who is not an ex-Seabee, for the benefit of the many DMs are ex-Seabees.

Caricatures. Drawing caricatures is very much like having the subject stand in front of a bent mirror found in carnivals and penny arcades. The mirror distorts and exaggerates the featues, but does not add or subtract anything not already existing about the subject. The cartoonist does the same thing. The predominant features are exaggerated or distorted, but you must be careful not to get away from the character.

Don't offend; exaggerate, but be reasonable. When possible, incorporate a hobby or anything identified with the subject. "Local color" always helps for a truer characteristic.

Capture at least one outstanding feature—a typical expression or mannerism. Put that down (slightly distorted) and draw around it. Once the head is drawn, the body can be drawn in. A good proportion for caricature is two-thirds head, and one-third body. The only possible way to learn to do caricatures is to practice. Strive for a likeness, then add small distortions to add humor.

Exercises (220):

1. How many different characters can be drawn from one head shape?

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CHAPTER 4

Composition and Layout

LAYOUT AND composition denote the selection and arrangement of appropriate elements within a picture so as to express the illustrator's idea clearly and effectively. The success of a picture depends on how well these elements are put together.

4-1. Composition

Composition, in a sense, is combining basic form and space—arranging the elements of the picture to produce a harmonious whole. In composing a picture, we are chiefly interested in what the finished product has to say. Regardless of the subject of your picture, the questions that you should ask yourself are: "What is or what isn't import to the picture, and what is the basic idea that you want to get across?"

Good illustrations don't just happen. They are the result of careful planning.

Name and define the main elements of composition.

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Elements of Composition. Composition is divided into four basic elements—area, depth, line, and value.

Area. Picture area is simply the borders in which you draw or paint your picture. To use this area most effectively, you must weigh carefully where you place the objects within the picture area and what size to make them. This is one of the primary reasons for a thumbnail sketch. It enables you to move a crude drawing around within the borders of a confined area for better planning. After each of these sketches is completed, ask yourself: "Does this create the effect I had in mind?" (Study foldouts 8, 9, 10, 11, and 12 of your supplement.)

The size we give to the objects of a composition and where they are placed control their importance in the illustration. Size should never be chosen without regard to the effect it will have on the final product. It is just as important as the action or the pose.

Depth. Depth, the second dimension of a drawing, is the creation of an illusion on a two-dimensional surface. The illusion created is distance. Overlapping, cropping, and making objects appear smaller with less detail are useful devices in creating a convincing sense of reality. The illusion of distance is not enough to give an illustration the sense of reality—it must be done in an intersting way. Don't ever be satisfied with the same basic arrangements; there are always new possibilities worth considering. Think, experiement, and try to make different and interesting uses of the varied shapes and objects in your picture.

Line. The term "line," as it is generally used in the preparation of art work, is the outline of a shape. As it applies to composition, "line" means the direction in which the eye moves to focus on a point of interst when looking at an illustration. Direction lines are created by the arrangement of the objects in the illustration so that the shape or the main lines lead the eye unconsciously to the center of interest. Controlling the movement of the viewer's eye within the picture is a very important function in picture construction. Line can be a strong or a subtle force in picture construction, but it should always lead the viewer to the center of interest.

Value. The fourth element of composition is value, the lightness or darkness of a picture. Value creates the mood or gives the overall key to a picture. In fact, light shades are frequently called ***high-key values*** and dark shades *low-key values.* For examples, a picture of children playing at a picnic is a gay and happy scene and should be fairly high-keyed, whereas, when portraying a fisherman on a lonely stretch of beach in the rain, the weather has set the mood. Line value is used to lead the viewer's eye to the point of greatest contrast. We can and do use this principle to focus attention.

Exercises (221):

1. What are the four elements of composition?

2. Which of the four creates a sense of reality?

4-2. Principles of Composition

The limitation of our nervous system defines not only the number and extension of the individual optical units which can be perceived as a whole, but also defines the lifespan of the visual experience. We cannot look at a static picture long without losing interest. However, an illustration based on sound principles will hold the observer's interest for a longer period of time. These are the principles of balance, proportion, rhythm, movement, unity, clarity, and simplicity. Let us study these principles.

222. Name and describe each of the seven principles of composition.

Balance. One of the most important principles of composition is known as balance. We are not used to seeing objects which appear to be toppling over. The leaning Tower of Pisa attracts our attention and interests us because it is precariously balanced. However, if or when the tower loses this balance, its attraction will cease to exist. An illustration or layout must also be balanced if it is to attract attention and maintain interest. This balance can take two forms, symmetric and asymmetric; or, as they are more commonly called, formal and informal.

Formal balance. Formal balance is obtained by placing each visual element squarely on an imaginary vertical centerline, or by duplicating each mass, shape, or line that appears on one side of this vertical in a corresponding position on the other side. The result is considered perfect symmetry. An example of formal balance is shown on the left side of figure 4-1.

Formal balance is commonly used in layouts, illustrations, and posters where the subject matter calls for reserve and dignity. However, since this type of balance produces a static composition without movement, it cannot hold the interest of the observer for very long. Therefore, an illustration, layout, or poster with formal balance must be simple so that the observer can understand it before he loses interest.

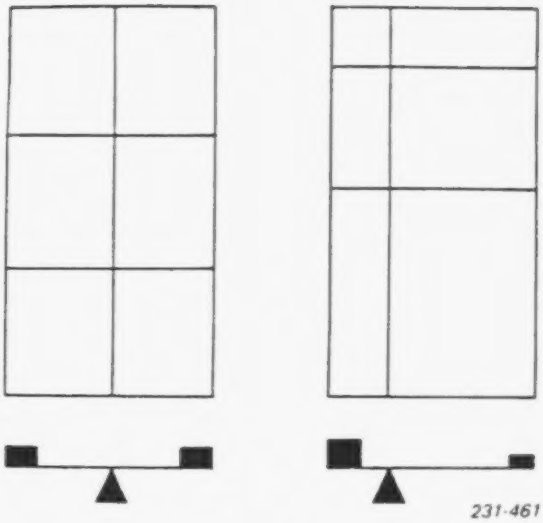

Figure 4-1. Balance.

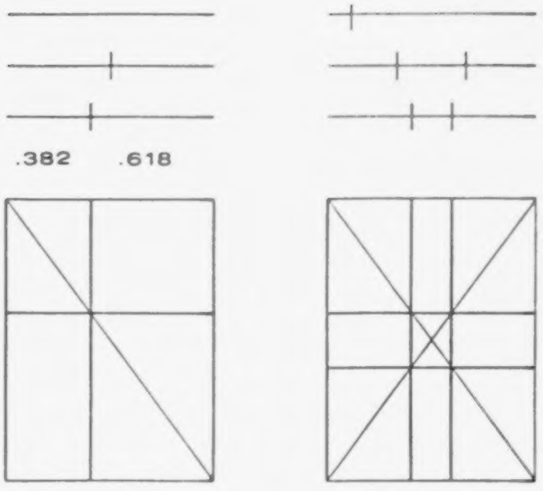

Figure 4-2. Proportion.

Informal balance. Notice how much more interesting the area of the rectangle is when divided as shown in the right side of figure 4-1. This is an example of informal balance. As you can see, a much greater variety of shapes and design can be used with this type of balance. However, the problem of balance is much more complex. The left side of the rectangular area must balance the right side, and the top half must balance the bottom half.

A large heavy mass placed on one side of the center may be balanced by a small one placed farther from the center on the opposite side. In the example shown, the heavier lines on the left are balanced by the large, light areas on the right. This type of balance is dynamic, the composition is alive, and there is movement caused by the interactions of the various shapes and lines.

When using informal balance, you must depend to a great extent on your own sense of balance, since no mathematical rules apply. The more elements you use, the more involved balance becomes.

Proportion. Another principle used to maintain interest and make a composition attractive is proportion. This adds variety to your picture. When a speaker talks in a monotone, you soon lose interest in his speech. When someone strikes the same note on a piano over and over again, you soon lose interest in its tone. This same effect can be found in drawings and illustrations. To prevent this from happening in your art work, you must divide the elements and the area of your illustration into varying sizes, ratios, or proportions. For example, look at the lines shown in the top portion of figure 4-2.

If we divide a line as shown on the top right, we do not actually get division. Instead, we merely chop off part of the line, and the small portion becomes insignificant and is lost. If we divide the line in half, we have a static division and a conflict of interest. We do not

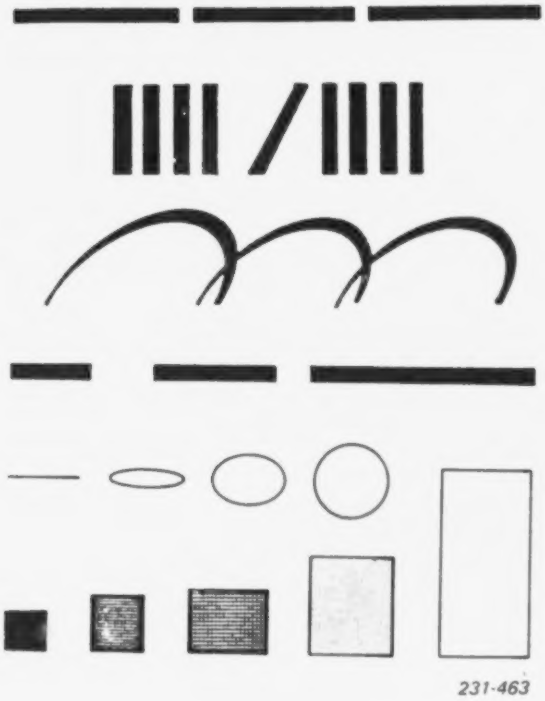

Figure 4-3. Rhythm.

know which half to look at and therefore cannot become intersted in either.

If we divide the line into thirds, we get a better division because the parts are repeated. This creates rhythm which is definitely more interesting.

When we divide the line between the one-half division and the one-third division, we get another division of equality. However, it is an equality of proportion. That is, the ratio of the smaller part to the larger part is equal to the ratio of the larger part to the whole line. This is known as the Golden Division of a line and is very important in composition.

As you can see in the lower half of figure 4-2, if the Golden Division rule is applied to an area such as a picture surface, interesting and related areas are created. The intersection of the two dividing lines locate an extremely strong point on the picture surface. For this reason, the center of interest in an ilustration or other form of art work should be located at or near this point on the picture surface.

If we divide the area of the picture plane by the Golden Division rule from both sides, top and bottom, we divide the area as shown in the diagram on the right side of figure 4-2. We now have four strong points at which we can place our center of interest.

If we draw lines between any of the points of the Golden Division, these lines form strong lines of construction for any composition. For example, if you

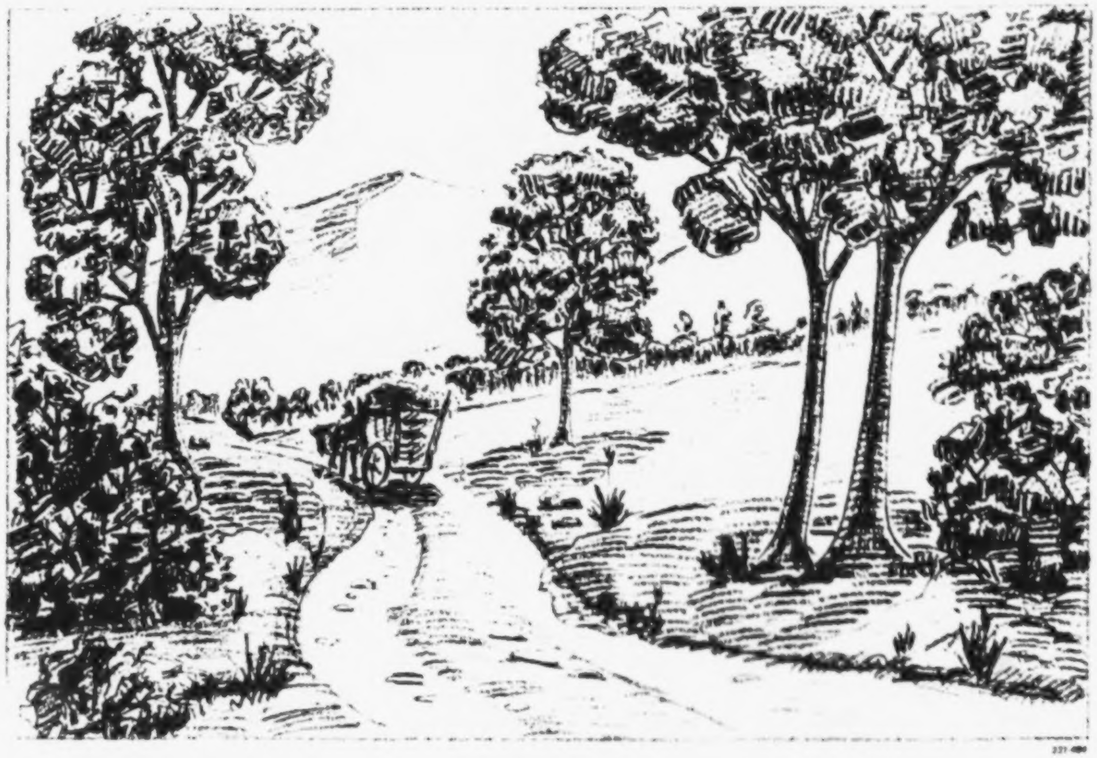

Figure 4-4. Progression.

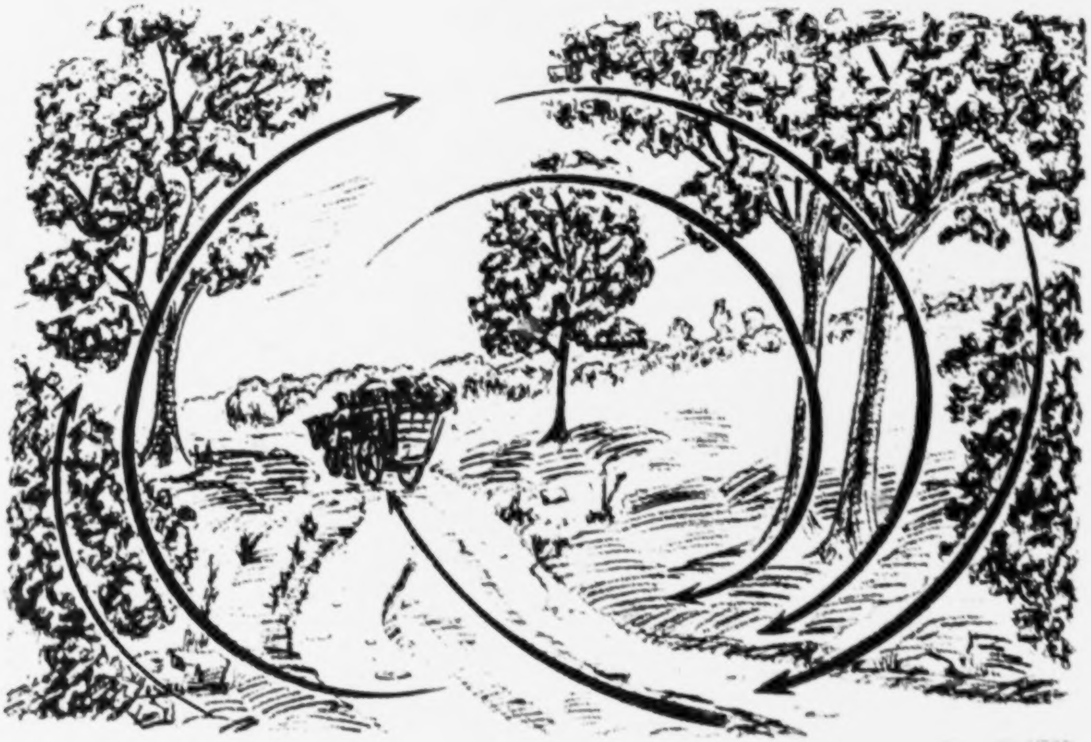

Figure 4-5. Movement.

are drawing a mountain, you should place the edge of the mountain on one of these strong lines of division.

Rhythm. We have mentioned before that interest can be maintained by rhythm. As you know, in music the beat or rhythm is an essential part of the tune. Rhythm in illustrating is just as important. We can obtain rhythm in two ways: by repetition and by progression.

Repetition. Rhythm can be obtained through regularly alternating or orderly repeating shapes, positions, lengths, angles, curves, direction, and intervals. A simple example of repetition is shown at the top half of figure 4-3.

Progression. Rhythm may also be obtained by slightly varying in the shape, value, size, and other factors. For example, in the bottom half of figure 4-3, a progression of lines is achieved by lengthening a line each time it is repeated. Revolving a circle also creates progression. In one position the circle appears as a line, next as a thin ellipse, then a thicker ellipse, and finally, a circle. Progression can be obtained in value as well as size and shape, as shown by the bottom elements. These elements also show progression of shape from a square into rectangles of different shapes.

Movement. Figure 4-4 shows the use of all of the principles of composition that we have discussed thus far. It uses balance, proportion, and rhythm. There is also present another important factor of composition—movement. This factor is perhaps the most important. As long as you can keep the eyes of the observer moving about the picture, you will hold his or her interest. These movements about our illustration are pointed out by figure 4-5. Notice that the movement is generally clockwise in direction. The eyes of the observer should be guided up the left side of a picture across the top, then down the right side and across the bottom. There may be intermediate paths of movement throughout the picture. All movement, however, should lead to the center of interest. You want to keep the observer interested until you can lead him to the point you want to show him most.

Unity, Clarity, and Simplicity. These three principles of illustrating are closely related. Combining elements into a unified whole is an important principle of composition. A composition without unity appears to fall apart and produces a disturbing effect.

Clarity is another principle you should follow in illustrating. Guard against blending elements to the extent of making them confusing to the observer. Clarity can be achieved by using legible lettering, tones which are not too close in value, and sharp clear lines.

The object of a layout or illustration is to command attention. Usually, the simpler a production is, the easier it is to get the observer to stop and look at it.

Since many elements have a tendency to divide the observer's attention, it stands to reason that the fewer elements you use, the easier it will be to make him concentrate on the few things you want him to notice. Therefore, omit all items that can be eliminated without impairing the purpose of your art work.

Exercises (222):

1. What are the principles of composition?

2. Why is the principle of balance important in the composition of an illustration?

3. The principle of unity is closely related to the principles of ____________ and ____________.

4-3. Layout

We stated in the previous section that good illustrations are the result of careful planning. This planning also includes sketching many basic ideas. Sketching your ideas allows you to see how well you are applying the basic rules of composition. It also allows you to see which combination of composition elements best portrays your ideas.

This series of sketches, which includes thumbnail sketches, roughs and comprehensives, is known as the layout process. We will look at the steps used in layout and explain the importance of each step.

223. State the purpose and function of a thumbnail sketch.

Thumbnail Sketches. Thumbnail sketches are small, quickly drawn illustrations used to formulate and work out the design of ides (fig. 4-6). They are called thumbnails because of their size, and are usually 1 to 3 inches square. Thumbnails are used primarily to work out general layout details, such as arrangement or composition, balance, movement, continuity, and other factors of design.

The first thumbnail shown in figure 4-7 is very much like the primary or preliminary sketch shown in figure 4-6. The results are not satisfactory because the composition is too static and uninteresting. Therefore, we try another. The composition or design of the second thumbnail is much less static than the first. Your eyes move throughout the design, first across the dark area representing lettering at the top of the thumbnail, down across the airplane, and across the dark area representing lettering across the bottom of the sketch. Still, the layout is rather old fashioned. The remaining four thumbnails show more interesting designs for our layout. Any one of these ideas might be used as our model. Notice that the last three sketches are quite similar and show how we can change the design slightly in searching for the best means of presenting our idea. This brings us to the next step in layout and composition development—the *rough sketch*.

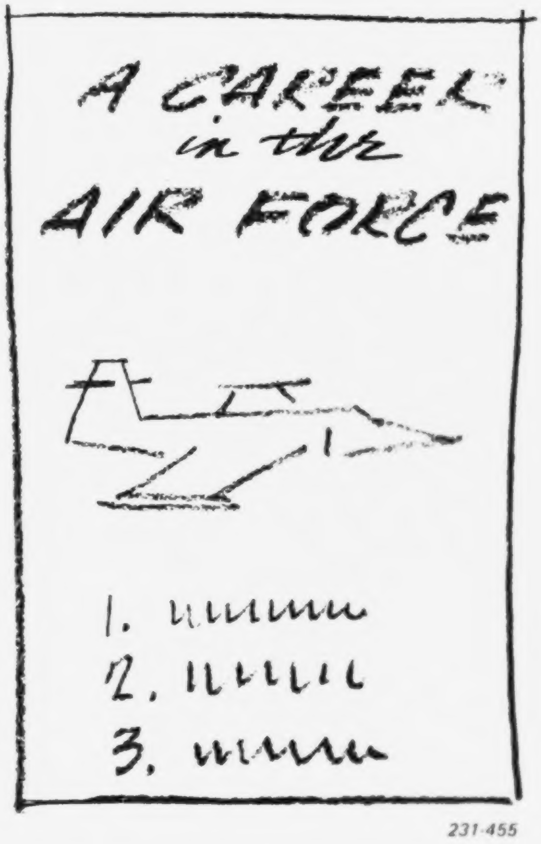

Figure 4-6. Preliminary sketch.

Exercises (223):

1. What is a thumbnail?

2. How is a thumbnail used?

224. Compare a thumbnail sketch and a rough sketch.

Roughs. After selecting one or two of the most promising thumbnail sketches, the usual procedure is to draw a more detailed sketch called a *rough*. Although a

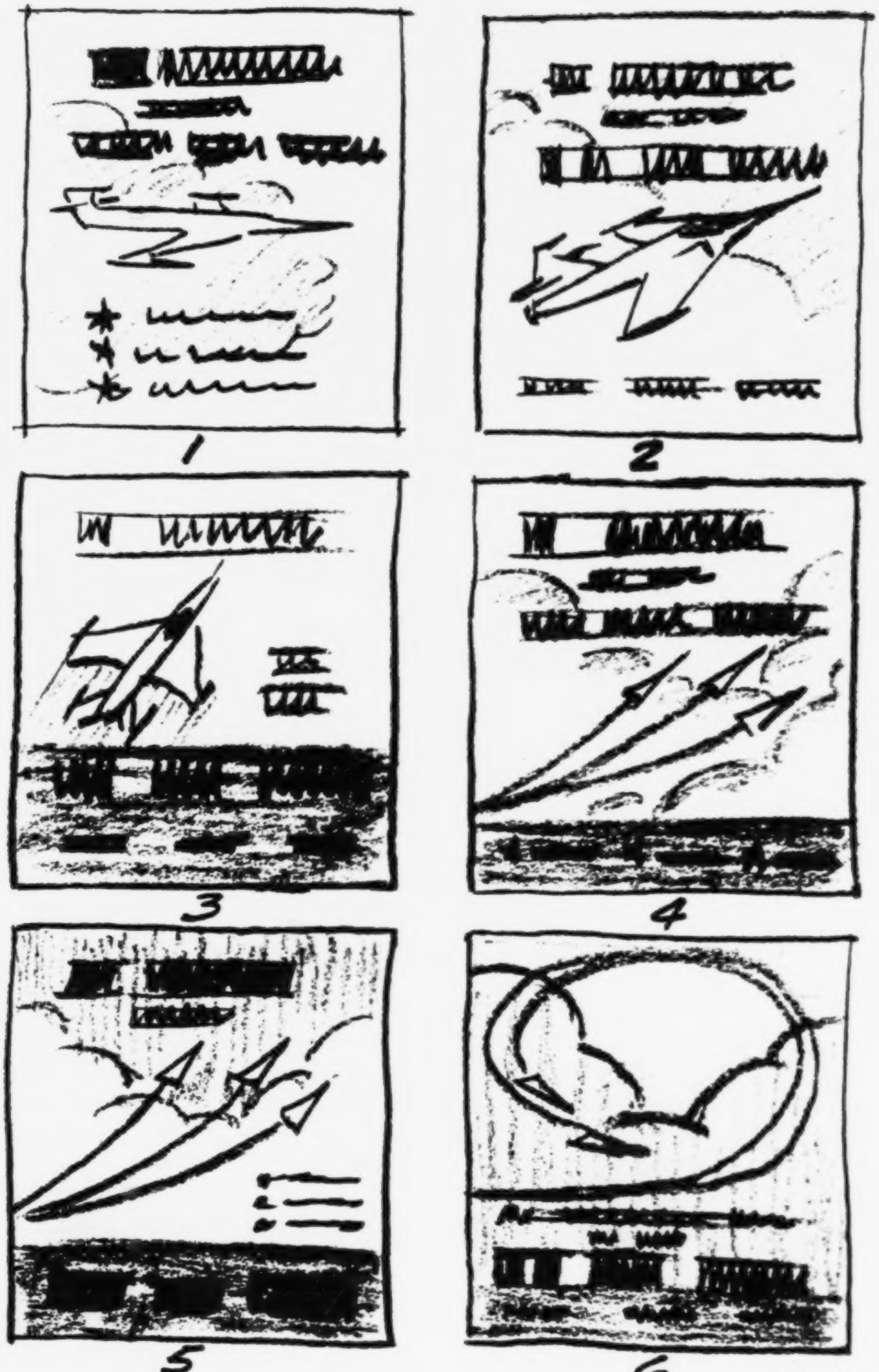
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Figure 4-7. Thumbnails.

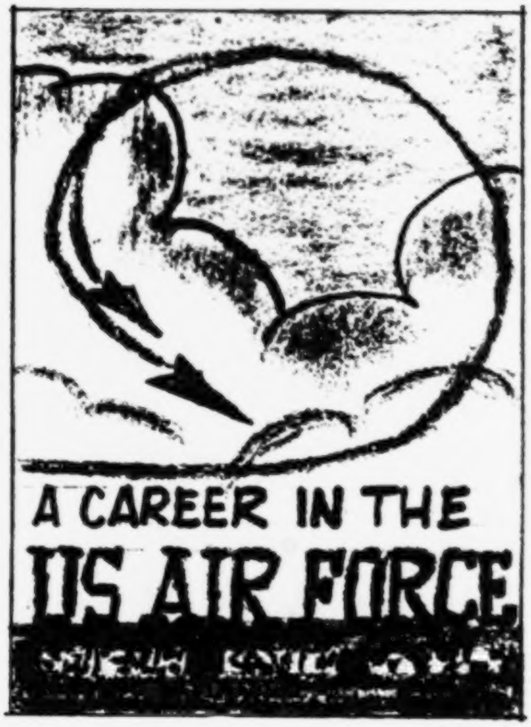

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Figure 4-8. Roughs.

good thumbnail can sometimes be used as a satisfactory model from which you can draw the finished art work, usually you need a more detailed drawing. The rough permits you to refine the design of a thumbnail sketch, to work out any details, and to show in a general way just how the finished illustration will look.

The rough should be drawn the same size as the final product. Of course, in the case of a poster where the size might be quite large, it would be impractical to make the rough the same size. However, if the poster is to be placed in some publications, then its size might be relatively small. Usually the finished art work for such a reproduction is drawn larger and reduced to the correct size by the printer. By drawing the rough the same size as the poster that will appear in print, we can see exactly how well the design of the poster works in the given space. Any faults in the design that are unnoticeable in the thumbnail usually become quite apparent in the rough and can be easily eliminated.

The illustration and lettering in the rough made from the thumbnails in figures 4-6 and 4-7 are made with a bold, simplified technique and a soft pencil (see fig. 4-8). This is the usual practice, although hard pastel, colored pencil, or tempera is often used. Notice that the rendering of the rough has a quick and incisive character that is easily distinguished from the painstaking, detailed rendering of the finished work of art. Colored papers are a great help when colored backgrounds or panels are necessary. Tempera is useful when indicating colored or reverse lettering on a pastel background. Smooth white bond paper, either opaque or semitransparent, and tracing paper are satisfactory for rough layouts. Refer to foldout 3 (printed as a separate supplement to this volume).

Exercises (224):

1. What is the difference between a thumbnail and a rough?

2. Why is a rough necessary?

225. State the purpose and function of a comprehensive.

Comprehensives. If you have done a good job on your rough, it will probably be adequate to use as a guide for the finished art work. However, there are times when the person for whom the art work is being done would like to know exactly what the finished product will look like before getting the same. To satisfy him, you must draw a comprehensive layout.

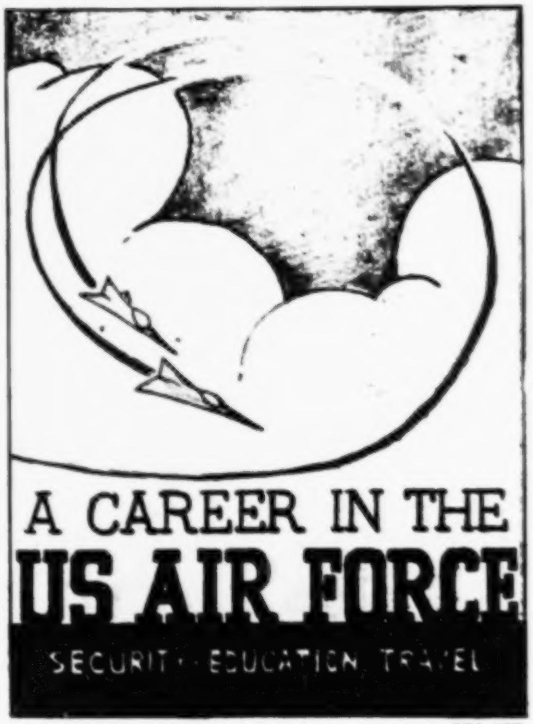

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Figure 4-9. Comprehensives.

A comprehensive is a detailed layout that is a step closer to the finished product than a rough. Comprehensives are used to show exactly what the finished product will look like. The tones, color, and details are all carefully drawn. In fact, sometimes a comprehensive is rendered with such precision that it could almost be used as the finished art work. If a more detailed drawing is needed for some complicated parts, you can make comprehensives of the parts. For example, in our sketch the drawing of the airplane is very general. In the finished art work, the drawing of the airplane is quite precise. Therefore, we can draw an accurate comprehensive of the airplane on tracing paper and use this drawing to trace the airplane on the final art work.

Comprehensives can also be used for other purposes (fig. 49). For example, comprehensives are used in connection with this course and the preparation of the SKT (Specialty Knowledge Test). Since the test items of an SKT are based on the information presented in the CDC, the people preparing the test items must have a complete CDC manuscript (including illustrations). The test must be ready at the same time or very shortly after the CDC becomes available. We think of these knowledges as fundamentals, because you will use them in nearly all phases of illustration.

Exercises (225):

1. What is a comprehensive layout?

2. Why use a comprehensive layout?

226. Describe the two methods of establishing a reference file.

Reference Files. One of the biggest assets to a graphics specialist is a good file of picture clippings from magazines, newspapers, catalogs, books, and other printed sources. This file is called a reference file, or "scrap" file. Making such a file is a time-consuming job, but you will be surprised at how much you will learn from this activity and what a marvelous timesaver it will become for your shop. In addition to being an excellent source of information, the reference file is a rich source of picture ideas. If there is no reference file at your command now, start one right away. If there is one, you must always be adding to it.

The job of selecting pictures for your reference file will help to develop your sense of observation. The average person is just a casual viewer when he is looking through magazines, books, and such. The pictures pass by, one by one in a constant parade; they are only recordings of things and places. But, as an illustrator, you should go through these publications with a definite purpose in mind. You are not just browsing but considering each picture for a specific place or category in your file or in relationship to your work. This will heighten your interest in the picture and the subject enormously. To decide whether a particular picture will be useful to you or not, you must study it objectively for as long a time as necessary for it to register in your subconscious mind. Inevitably you will retain something of it, and your powers of observation will be sharpened.

How to start a reference file. The picture file you start is useful only if it is kept as orderly as your regular files.

The system described here is very basic but can be easily expanded as material is added.

Because you will want to file many pieces of material which may be quite small, it is best to use lettersize folders which have tabs for identification. In this way, all of the material under a particular category may be filed together with less chance of its becoming lost.

Picture sources. Magazines, books, and newspapers are the best sources for pictures. Almost any magazine contains photographs worth clipping. The best ones, of course, are the picture magazines, the home and garden, fashion, and travel publications. Many cheap and otherwise useless books may have pictures you can clip. Newspapers are sources for material on current events, fashions, auto accidents, sports, political cartoon features, and countless other subjects.

Clipping. Start by prying out the staples and taking the magazine apart. When a picture is too large for your folder, fold it with the picture side out. If you cut away any descriptive text or if the caption does not identify the picture sufficiently, write on the picture such information as necessary to identify it. Date each picture with both year and month and write the publisher's name on it so you can identify its source.

Material you clip may be covered by a copyright. Reproducing or publishing a copyrighted work without permission is considered as an infringement of copyright and is punishable by a fine for each violation. AFR 110–8 prescribes Air Force policies and procedures pertaining to the use of copyrighted materials.

What to Clip. You should have clippings on almost every subject. You may not be interested in every subject the day you clip it, but next month or next year you may have to make a picture of it. Most fashion photographs are less valuable for the fashions than for the chair used by the model or some other decorative note. Some pictures may seem too small, but they may be worth saving for some ideas they contain. An intriguing pose, dramatic lighting effect, or unusual action may suggest a picture to you someday. The file is not only a reference but also an outstanding source for ideas, suggesting the mood or atmosphere for your particular assignment.

Organization of Art Files. There are few guidelines in setting up art files. Here are a couple of examples that are widely used. You may want to establish your own filing system. The key is organization.

Two filing systems. The first example lists major subjects alphabetically and then beneath each major head lists subordinate subjects (also alphabetically), as shown below:

Airplane
    Commercial
    Private
    WWI
    WWII

Birds
  Birds of prey
  Game
  Nocturnal
  Scavengers

The second method is a straight alphabetical listing without subordinate subjects, as in the following example:

Airplanes
Automobiles
Birds
Buildings
Cartoons
Dogs

What you use to build your file is entirely up to you, your interests, and most often the type of work you are doing. There are no restrictions as to what goes into your file. This brings us to the question, "Where do I keep this pile of invaluable resource materials?" The answer depends on what is available. You may place your large envelopes or file folders in a reinforced cardboard box, desk drawer, or a metal file cabinet. You can also organize your file materials in a number of scrapbooks, according to subject matter. Remember that the key is organization.

Exercises (226):

1. What is the main purpose of establishing an art file?

2. What is the key factor in the success of an art file?

3. Do you think it would be important to establish a reference file at your new duty assignment? If so, why?

4. What should you do if the caption does not sufficiently describe the picture?

5. Which Air Force regulation covers the use of copyrighted materials?

Answers for Exercises

CHAPTER 1

Reference:

200 – 1. The sphere, the cylinder, the cone, and the cube.
200 – 2. Form.

201 – 1. The illusion that gives an object a third dimension.
201 – 2. The process of drawing all sides of an object, even those that are unseen.

202 – 1. To emphasize form in the drawing.

203 – 1. Opacity of the ink and its capacity to contrast sharply with the illustration surface.
203 – 2. A croquill.
203 – 3. Clear; sharp; consistent.
203 – 4. Crosshatching.

204 – 1. Textured or rough.

205 – 1. Chemically developed shading medium, transparent film patterns, and tones.
205 – 2. Timesaving and special effects.
205 – 3. By overlapping the same patterns or different patterns of transparent film.

206 – 1. The rubbing with either a stump or the finger will cause a blending into a smooth grayed tone.
206 – 2. Carbon or lithographic pencils have a dark, mat-finish. Lead or graphic pencils leave a shiny grayed surface.

207 – 1. A wash illustration is an illustration painted with a diluted pigment in water to produce a transparent effect.
207 – 2. Since a wash is laid on an inclined surface, it must be started at the top so that the diluted pigment will settle toward the bottom, producing an even tone.
207 – 3. Soft, fluid effects in wash are obtained by working in the area while the wash is still wet.
207 – 4. By laying masking tape along the edge and applying the wash right up to the tape.

208 – 1. Sir Isaac Newton.
208 – 2. Dispersion is the separation of light rays into bands of color.
208 – 3. Spectrum is the resulting bands of color caused by dispersion.

209 – 1. (1) b; (2) b; (3) a; (4) c; (5) b; (6) c; (7) a; (8) b.
209 – 2. The same pigment colors when mixed will not produce all colors. It is impossible, for instance, to produce yellow by mixing colored pigments.
209 – 3. (1) b and c.
(2) a and b.
(3) a and c.
209 – 4. A 12-hue wheel is convenient because it exactly accommodates the 3 primary, 3 secondary, and 6 tertiary colors.
209 – 5. Complementary colors are located directly opposite each other on the color wheel.
209 – 6. The environment affects the hue, value, and intensity of the color. It can even cause an apparent change in the size of the area occupied by the color.

210 – 1. Red, yellow, and orange are considered warm colors, while blue-green, blue, and blue-violet are considered cool colors.
210 – 2. Monochromatic schemes are most likely to be monotonous.
210 – 3. Complementary.
210 – 4. Contrasts.
210 – 5. Triad.

211 – 1. Versatility.
211 – 2. The time it takes for the paints to dry.
211 – 3. Because they can be handled as either oils or watercolors.
211 – 4. Be of medium or heavy weight, absorbent, and have a textured surface.
211 – 5. Tempera is a stiff, opaque watercolor that lacks the transparency of watercolors. Tempera is used to lay down flat tones instead of transparent washes.
211 – 6. Hard, semi-hard, and soft.
211 – 7. Because the pigments won't smudge or blend easily.
211 – 8. A good colored pencil should have a thick lead, make a soft and waxy mark on the paper, have a good color buildup, and have uniform and brilliant hues.
211 – 9. "Mixed-media" is a combination of any two or more mediums.

CHAPTER 2

212 – 1. 8 heads.
212 – 2. Less muscle development and a heavier layer of fatty tissue.

213 – 1. The chest, the abdomen, and the pelvis.
213 – 2. A modified cone.

214 – 1. Oval.
214 – 2. The femur.

215 – 1. The eyes.
215 – 2. The eyes.
215 – 3. The nose and ears.

216 – 1. The hands.
216 – 2.
  a. Square.
  b. Palm.
  c. Forearm; hairline.
  d. Wrist.
  e. Thumb.
  f. Concave; convex.

217 – 1. The ability to feel the physical qualities of a subject through observation.
217 – 2. That your pencil is touching the subject at the point where your eyes are focused.
217 – 3. To study the action or expression of the subject.
217 – 4. In its entirety.

218 – 1. Foreshortening is the illusion created that makes an irregular (free) form appear to go toward or recede from the viewer.
218 – 2. Main consideration:
  a. Proper use of vanishing point.
  b. Eye level of observer.
  c. Light source.

CHAPTER 3

219 – 1. A simplified, exaggerated form that shows expressions.
219 – 2. Face; eyes.

220 – 1. As many as the mind can imagine.

CHAPTER 4

221 – 1. Area, depth, line, and value.
221 – 2. Depth.

222 – 1. Balance, proportion, rhythm, movement, unity, clarity, and simplicity.
222 – 2. Because balance is used to hold the interest of the observer.
222 – 3. Clarity; simplicity.

223 – 1. A small, quickly drawn illustration.
223 – 2. To work out design ideas.

224 – 1. Instead of being small and quickly drawn, the rough is a drawing of actual size and is a more detailed sketch.

224 – 2. Any faults in the design that are unnoticeable in the thumbnail are quite apparent in the rough.

225 – 1. A detailed layout that is a step closer to the finished product.
225 – 2. To show exactly what the finished product will look like.

226 – 1. The main purpose for establishing an art file is to establish an excellent source of information and a real source for ideas.
226 – 2. The key factor in the success of an art file is organization.
226 – 3. It is important to establish a master reference file at your new duty assignment because such a file is a timesaving device for information and ideas.
226 – 4. If the caption does to identify the picture sufficiently, write on the picture such information as necessary to identify it.
226 – 5. The Air Force Regulation that covers the use of copyrighted materials in AFR 100–8.

STOP-
1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

23151 02 22

BASIC DRAWING

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover *your* answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor. If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the *best* answer to each question.

1. (200) Which of the following is *not* considered one of the four basic forms of drawing?

   a. Cylinder.
   b. Circle.
   c. Cone.
   d. Cube.

2. (200) The foundation of the training of a graphic specialist is the principle of

   a. combining colors.
   b. using light and shade.
   c. drawing form.
   d. drawing depth.

3. (201) The term "drawing through" means that you are

   a. adding a background to your drawing.
   b. making an original drawing through the use of an optical drawing aid.
   c. attempting the three-dimensional effect of depth.
   d. merely putting the finishing touches on an otherwise completed drawing.

4. (201) The proper application of the principle of drawing through will give your picture the effect of looking

   a. recessive.
   b. too detailed.
   c. lopsided.
   d. real.

5. (202) You have just completed drawing a basic form using the draw-through principle. What, if anything, should you do to enhance the appearance of this basic form?

   a. Add lighting or shading to emphasize the form.
   b. Do nothing as the form will stand by itself.
   c. Add a dark background.
   d. Add a light foreground.

6. (203) In the pen-and-ink technique of line drawing, India ink is most commonly used because it

   a. is permanent.
   b. is opaque.
   c. is waterproof.
   d. has all of the above characteristics.

7. (203) The techniques of crosshatching, graded lines, parallel lines, and stipple relate to a drawing's

   a. depth.
   b. form.
   c. texture.
   d. tone.

8. (204) In a line media illustration produced with pencil or crayon, the drawing is usually applied to what type of surface?

   a. Smooth.
   b. Lined.
   c. Textured.
   d. Colored.

9. (204) The reason a textured surface is used for a line media drawing with a pencil is that it

   a. gives the required sharpness and contrast.
   b. produces a pattern that gives a tonal effect.
   c. can be erased many times without degradation.
   d. produces a matte effect.

10. (205) What are the two types of prepared shading media?

a. Transparent film and chemical.
b. Transparent film and paper.
c. Chemical and paper.
d. Chemical and opaque.

11. (206) Which of the following gives a matte finish and a rich dark black?

a. Crayon.
b. Carbon pencil.
c. Lead pencil.
d. Graphite pencil.

12. (206) What would be the effect of using a pencil on rough textured paper?

a. A half tone effect.
b. A dark matte effect.
c. A fluid effect.
d. A granular effect.

13. (207) What advantage does India ink have over lampblack or Chinese stick ink when you are preparing and laying a wash?

a. It is easier to use.
b. Lampblack and stick ink must be strained.
c. Chinese stick ink and lampblack are messy.
d. One wash can be laid over another without picking up the one underneath.

14. (208) The separation of light into colors is called

a. value.
b. density.
c. dispersion.
d. light separation.

15. (208) A black object is one that

a. absorbs nearly all light rays.
b. reflects nearly all light rays.
c. reflects all colors except black.
d. absorbs all colors except black.

16. (209) The color quality that enables us to discriminate between light red and dark red is

a. chroma.
b. hue.
c. intensity.
d. value.

17. (209) The quality by which we recognize one color from another is called

a. intensity.
b. value.
c. hue.
d. density.

18. (209) Which of the following colors is considered cool?

a. Red.
b. Blue.
c. Yellow.
d. Orange.

19. (209) Based on Brewster's concept of the primary pigment colors as red, yellow, and blue, name the secondary colors.

a. Orange, citron, green.
b. Orange, green, violet.
c. Olive, russet, citron.
d. Russet, orange, green.

20. (210) When a single color value varies from a light tint to a dark shade, the color is said to be

a. analogous.
b. monochromatic.
c. complementary.
d. triadic.

21. (210) An analogous color is sometimes called a

a. triad color scheme.
b. complementary color scheme.
c. related color scheme.
d. monochromatic color scheme.

22. (210) A color scheme made up of orange, yellow, and green would be

a. analogous.
b. complementary.
c. monochromatic.
d. near-complementary.

23. (210) You can prevent an analogous scheme from becoming monotonous by

a. taking in more of the color wheel.
b. introducing white as an accent.
c. placing emphasis on a hue that is not dominant.
d. introducing complementary accents.

24. (211) All oil painting surfaces must be

a. stretched on a frame.
b. completely smooth.
c. tinted.
d. sized and primed.

25. (211) The *primary* reason for using medium or heavy weight watercolor paper is that it

a. resists buckling.
b. is easier to mount.
c. is less likely to tear.
d. is easier to correct.

26. (211) Why is tooth necessary on pastel paper?

a. To maintain a sharp image.
b. To hold the particles of pigment.
c. To strengthen the expression of form.
d. To form delicate backgrounds.

27. (211) What is the key to colored pencils?

a. Erasability.
b. Waxing.
c. Sgraffito.
d. Transparency.

28. (212) How many head units high is the preferred height of an illustrated human figure?

a. 6½.
b. 7.
c. 7½.
d. 8.

29. (212) An illustration of a twelve-year-old-boy should be

a. 8 head units high.
b. 7 head units high.
c. 6 head units high.
d. 5 head units high.

30. (213) The torso of the human figure is composed of how many masses?

a. 1.
b. 2.
c. 3.
d. 4.

31. (213) The part of the torso which serves as a base for the other parts of the body is the

a. abdomen.
b. rib cage.
c. pelvis.
d. epigastrium.

32. (213) In an illustrated figure of the human body, the chest, abdomen, and the pelvis should be connected by the

a. rib cage.
b. shoulder girdle.
c. collar bone.
d. spinal column.

33. (214) How many bones are contained in the upper and lower arm?

a. 3.
b. 4.
c. 5.
d. 6.

34. (214) What is the shape of the leg and calf of the human form?

a. Square.
b. Triangular.
c. Circular.
d. Elliptical.

35. (214) Which bone of the human body is considered to be the longest and the strongest?

a. Ulna.
b. Radius.
c. Humerus.
d. Femur.

36. (214) In a drawing of the human leg, the ankle is represented as a

a. square.
b. triangle.
c. reverse curve.
d. inverted wedge.

37. (215) In comparison to the nose, the ear is normally

a. three-fourths as long.
b. two-thirds as long.
c. somewhat longer.
d. the same length.

38. (216) What part or parts of the body, other than the face, are most expressive?

a. Feet.
b. Arms.
c. Hands.
d. Torso.

39. (216) The length of the feet is approximately

a. twice that of the middle fingers.
b. three-fourths the distance from the elbows to the wrists.
c. one-third the distance from the pelvis to the knees.
d. one-half the distance from the knees to the bottom of the feet.

40. (217) Gesture drawings are used for what purpose?

a. To teach you to draw quickly.
b. To achieve a photographic likeness.
c. To study the action and expression of the subject.
d. To teach you to see the entire subject at one time.

41. (218) An irregular form appearing to recede from or come toward the viewer causes a phenomenon known as

a. free form.
b. foreshortening.
c. refraction.
d. perspective.

42. (219) The *main* difference between cartoon and figure drawing is in

a. simplification of features.
b. foreshortening.
c. movement.
d. balance.

43. (219) Cartoon facial expressions are produced by the movement or lack of movement of which of the following facial parts?

a. Mouth.
b. Forehead and eyes.
c. Nose.
d. All of the above.

44. (220) Which one of the following is *not* one of the recommended techniques for cartoons or caricatures?

a. Use the established public impressions of the individual.
b. Draw correct human proportions, within reason.
c. Know the people who will be viewing your characters.
d. Strive for a likeness; then add small distortions for humor.

45. (221) What are the basic elements of composition?

a. Depth, value, and color.
b. Area, depth, line, and value.
c. Line, value, and color.
d. Area, depth, value, and pose.

46. (221) The creation of an illusion of distance on a two-dimensional surface is called

a. depth.
b. area.
c. value.
d. composition.

47. (221) The term "line" when used in conjunction with composition means

a. the number of lines used in the construction of the drawing.
b. the direction in which the eye moves to focus on a point of interest in an illustration.
c. the number of complex vertical lines which lead to the main point of interest.
d. all of the horizontal and vertical lines used in the composition of the drawing.

48. (221) The element of composition which creates the mood or gives the overall key to a drawing is called

a. color.
b. line.
c. focus.
d. value.

49. (221) An illustration of a downed aircraft in the Dismal Swamps of North Carolina would be best portrayed using shades having

a. high key values.
b. normal key values.
c. low key values.
d. very thin key values.

50. (222) The seven principles of composition are balance, proportion, rhythm, movement,

a. clarity, conciseness, and definition.
b. design, attention, and mood.
c. simplicity, distinctness, and mass.
d. unity, clarity, and simplicity.

51. (222) Golden Division serves the purpose of determining

a. centers of interest.
b. color balance.
c. formal balance.
d. unity.

237

52. (222) A large mass balanced by a small mass in an illustration is known as

a. informal balance.
b. geometric balance.
c. formal balance.
d. symmetric balance.

53. (223) The type of illustration usually used in the initial working out of general layout details is the

a. comprehensive layout.
b. process drawing.
c. rough sketch.
d. thumbnail sketch.

54. (224) The "rough" should be drawn to

a. one-half the size of the original.
b. the same size as the final drawing.
c. any scale that the illustrator wishes to use.
d. a size that shows only the important parts of the design.

55. (225) A comprehensive drawing is

a. usually accomplished after a thumbnail sketch has been made.
b. always made to the same size as a thumbnail sketch.
c. normally finished in pastel colors.
d. used to show what the final product will look like.

56. (226) The main purpose of the landscape is to

a. serve as the chief subject of an illustration.
b. set the scene for the center of interest.
c. serve as a fill-in for the total picture.
d. set a reference for time of day.

END OF EXERCISE

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012 and EO 9397. **PRINCIPAL PURPOSES:** To provide student assistance as requested by individual students. **ROUTINE USES:** This form is shipped with ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. **DISCLOSURE:** Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance to the student.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: *(Mail to: ECI, Gunter AFS AL 36118)*

1. THIS REQUEST CONCERNS COURSE (1 - 6)	2. TODAY'S DATE	3. ENROLLMENT DATE	4. AUTOVON NUMBER
5. SOCIAL SECURITY NUMBER (7 - 15) ☐☐☐ - ☐☐ - ☐☐☐☐	6. GRADE/RANK	7. NAME *(First initial, second initial, last name)* (17) (18) (19-32)	

8. ADDRESS *(OJT Enrollees -- Address of unit training office with zip code. All others -- current mailing address with zip code.)*
(33-53)
(54-75)

9. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE

10. TEST CONTROL OFFICE ZIP CODE/SHRED (33 - 39)

SECTION II: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an 'X' through number in box to left of service requested)

1 Request address change as indicated in Section I.
2 Request Test Control Office change as indicated in Section I.
3 Request name change/correction (Provide Old or Incorrect data)
4 Request Grade/Rank change/correction.
5 Correct SSAN. (List incorrect SSAN here) (Correct SSAN should be shown in Section I)
6 Extend course completion date. (Justify in REMARKS)
7 Request enrollment cancellation.
8 Send VRE answer sheets for Vol(s): 1 2 3 4 5 6 7 8 9 Originals were: ☐ Not received ☐ Lost ☐ Misused
9 Send course materials. (Specify in REMARKS) ☐ Not received ☐ Lost ☐ Damaged
10 Course exam not yet received. Final VRE submitted for grading on ________________ (date).
11 Results for VRE Vol(s) 1 2 3 4 5 6 7 8 9 not yet received. Answer sheet(s) submitted ____________________ (date).
12 Results for CE not yet received. Answer sheet submitted to ECI on ________________ (date).
13 Previous inquiry (☐ ECI Fm 17, ☐ Ltr, ☐ Msg) sent to ECI on ________________ (date).
14 Give instructional assistance as requested on reverse.
15 Other (Explain fully in REMARKS)

FOR ECI USE ONLY

16		
G	33	
K	Vol 33 - 35	GR 36 - 38
M	33 - 34	35 - 40
N	33 - 38	
P	Vol 33 - 35	TC 36 - 37
Q	33 - 34 00	Volume 35 - 37
38 1	39 - 42	
2	39 - 42	
3	39 - 42	
16		

REMARKS *(Continue on Reverse)*

OJT STUDENTS must have their OJT Administrator certify this request.	I certify that the information on this form is accurate and that this request cannot be answered at this station. *(Signature)*
ALL OTHER STUDENTS may certify their own requests.	

ECI FORM 17 OCT 82 (PREVIOUS EDITIONS MAY BE USED)

SECTION III: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of subject matter should be forwarded directly to preparing agency. For an immediate response to these questions, call or write the course author directly, using the AUTOVON number or address in the preface of each volume. All other inquiries concerning the course should be forwarded to ECI.

VRE Item Questioned:

Course No ____________

Volume No ____________

VRE Form No _________

VRE Item No _________

Answer You Chose ________
(Letter)

Has VRE Answer Sheet
been submitted for grading?

☐ Yes ☐ No

REFERENCE
(Textual reference for the
answer I chose can be
found as shown below)

In Volume No ___________

On Page No ____________

In ☐ left ☐ right column

Lines ____ Through ______

MY QUESTION IS:

REMARKS

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. Course workbooks have a Form 17 printed on the last page.

23151 02 S01 8305

SUPPLEMENTARY MATERIAL

CDC 23151

GRAPHICS SPECIALIST

(AFSC 23151)

Volume 2

AUGAPS, AL (862007) 600

Foldouts 1 through 12

Extension Course Institute
Air University

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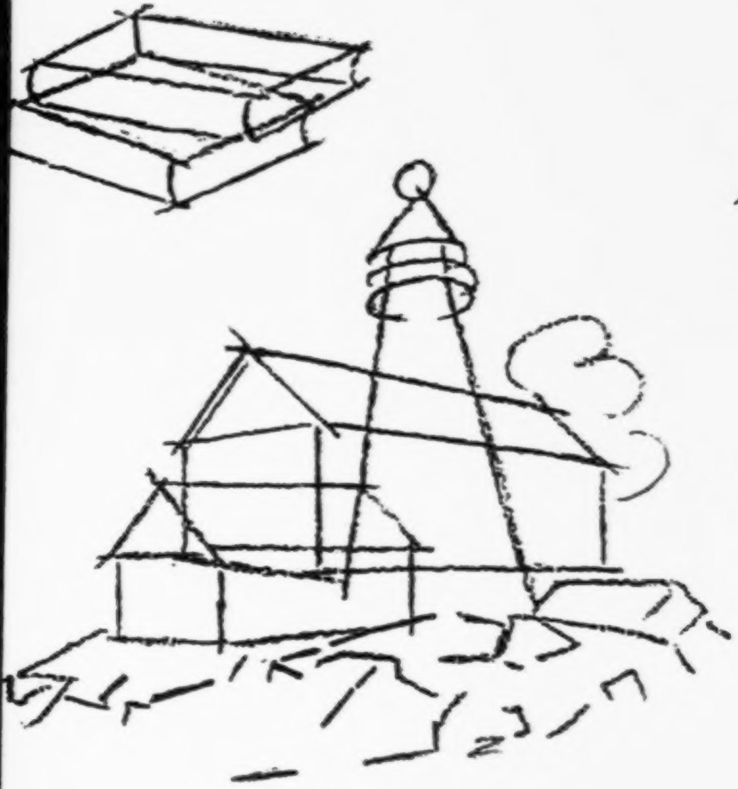
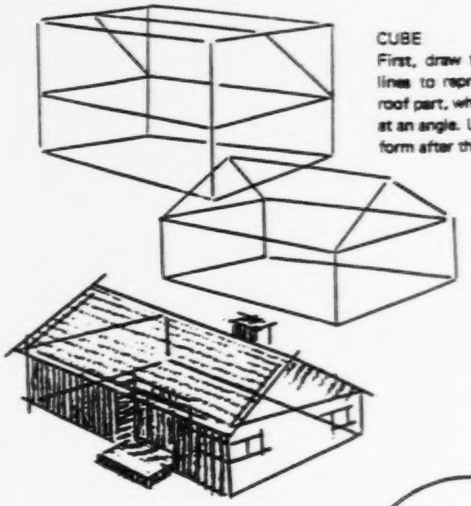
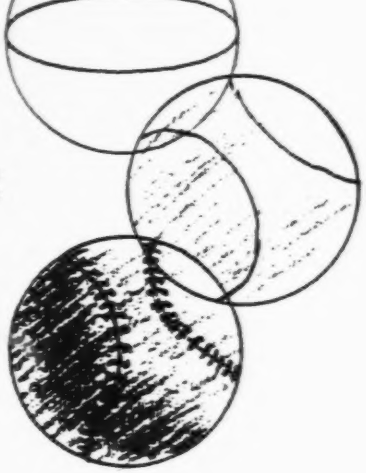




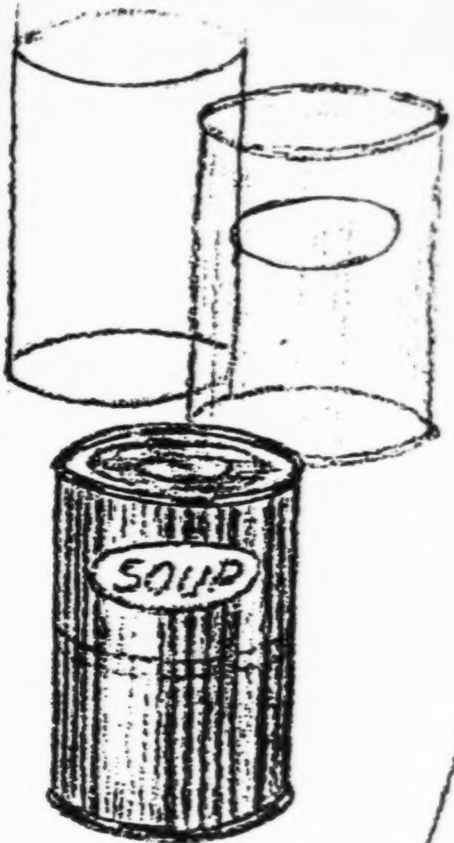
CUBE
First, draw the base of the cube, then the lines to represent the walls. Next, add the roof part, which is a section of a cube turned at an angle. Light and shade to emphasise the form after the basic construction.

SPHERE
The sphere suggests any form that is round or oval. Add shading and it will give realism to any form.



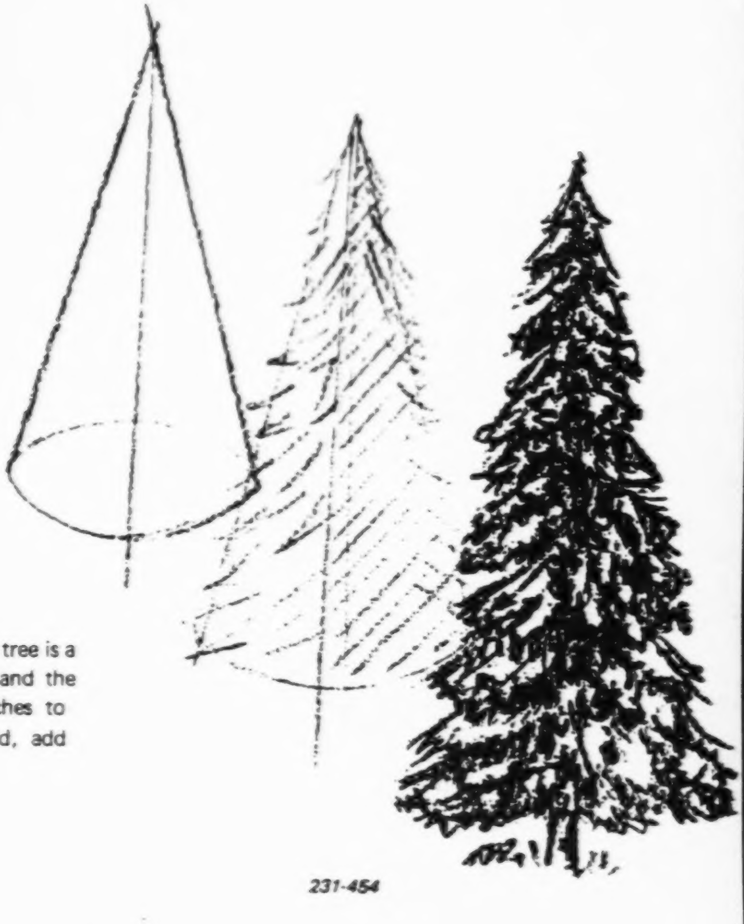
DRAWING THE BASIC FORM

In drawing the basic forms, each form is drawn through first as a basic form then the details.



CYLINDER

The can is essentially a cylinder, so when you start the drawing - - draw a cylinder. To help the basic shape of the can, light and shade should be established. Shading gives the form a needed emphisis.

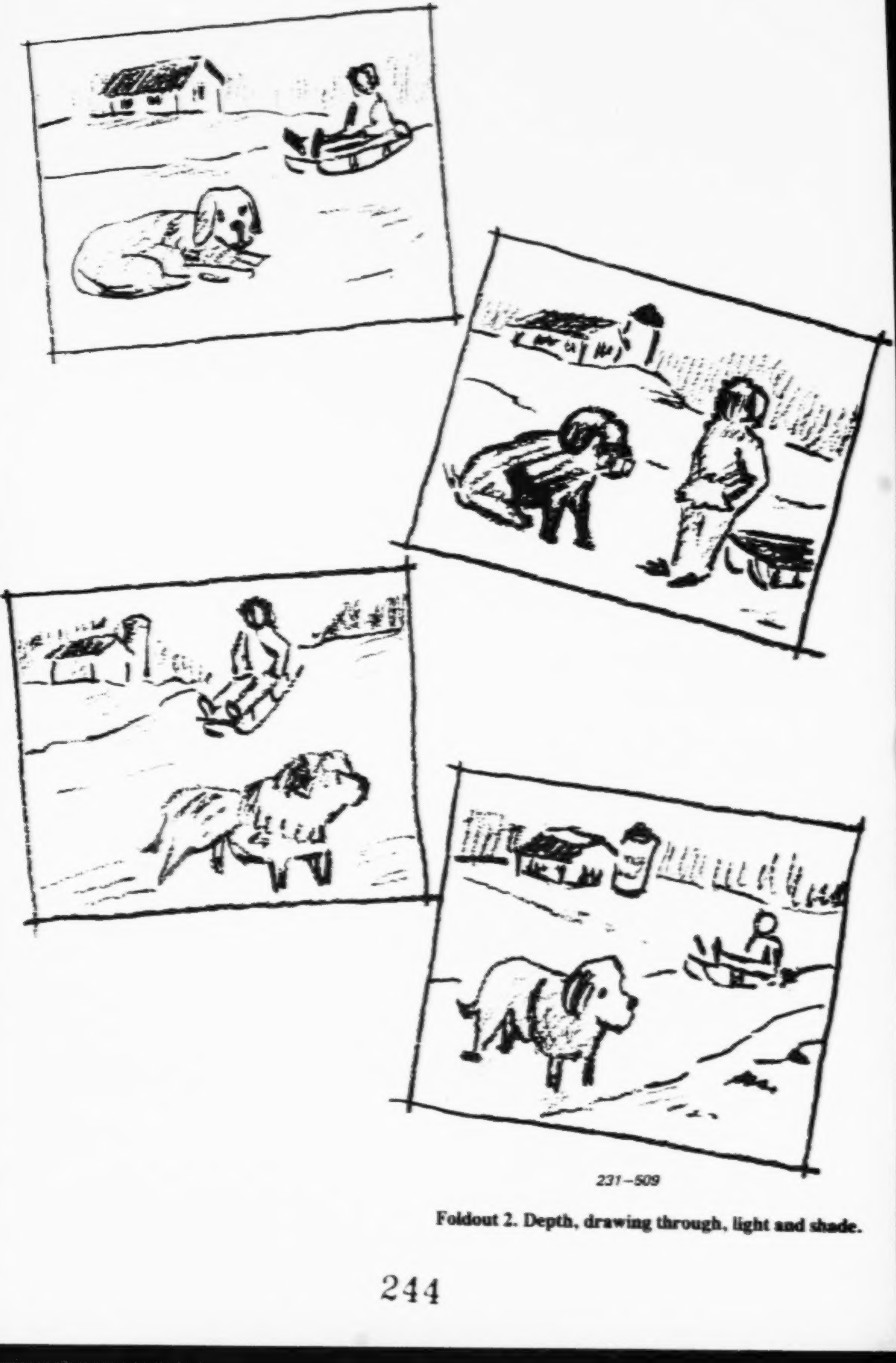


CONE

.The basic shape of the pine tree is a cone. The use of shading and the drawing of irregular branches to make the form look solid, add realism.

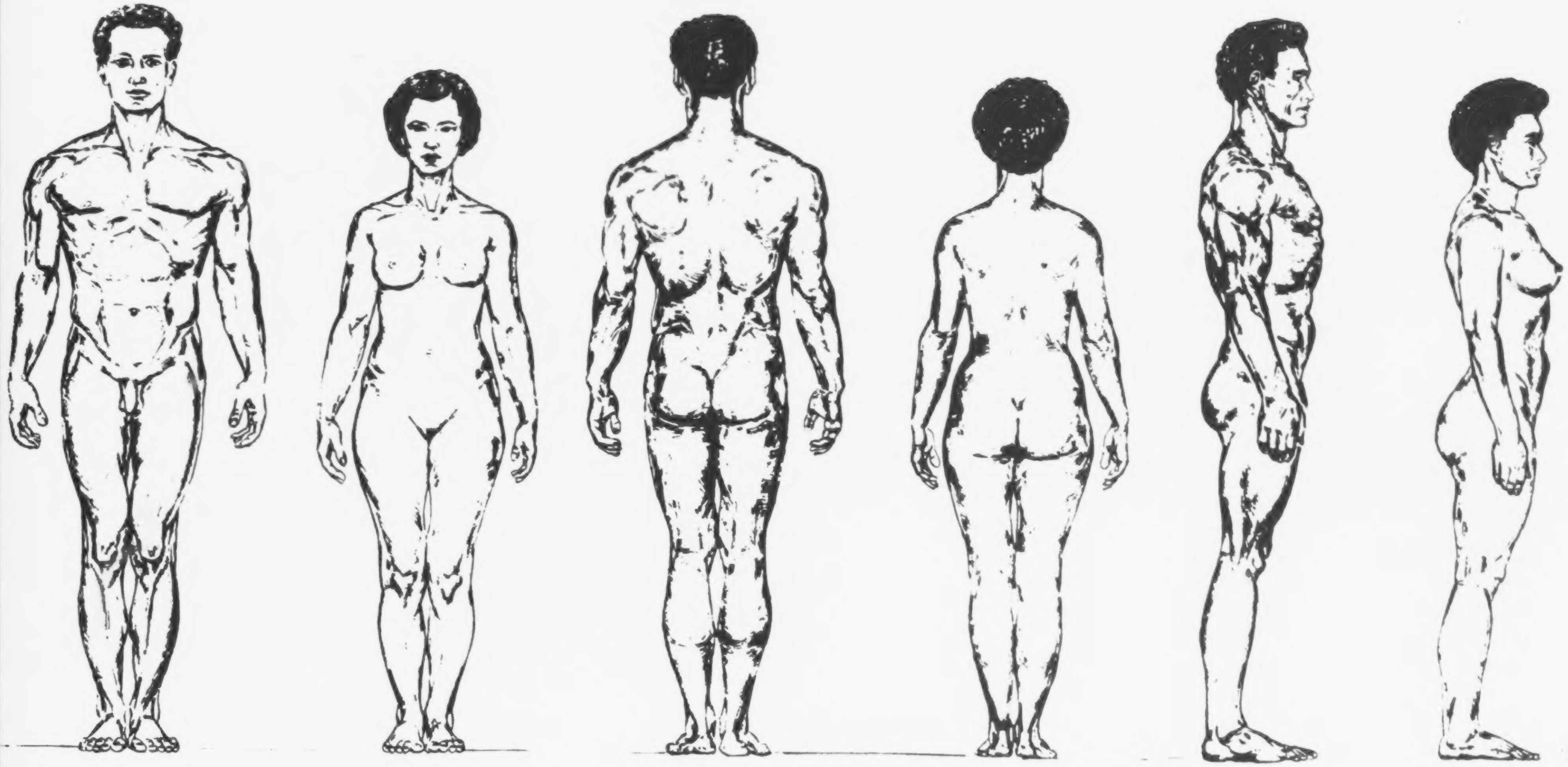
231-454

Foldout 1. Drawing basic form.

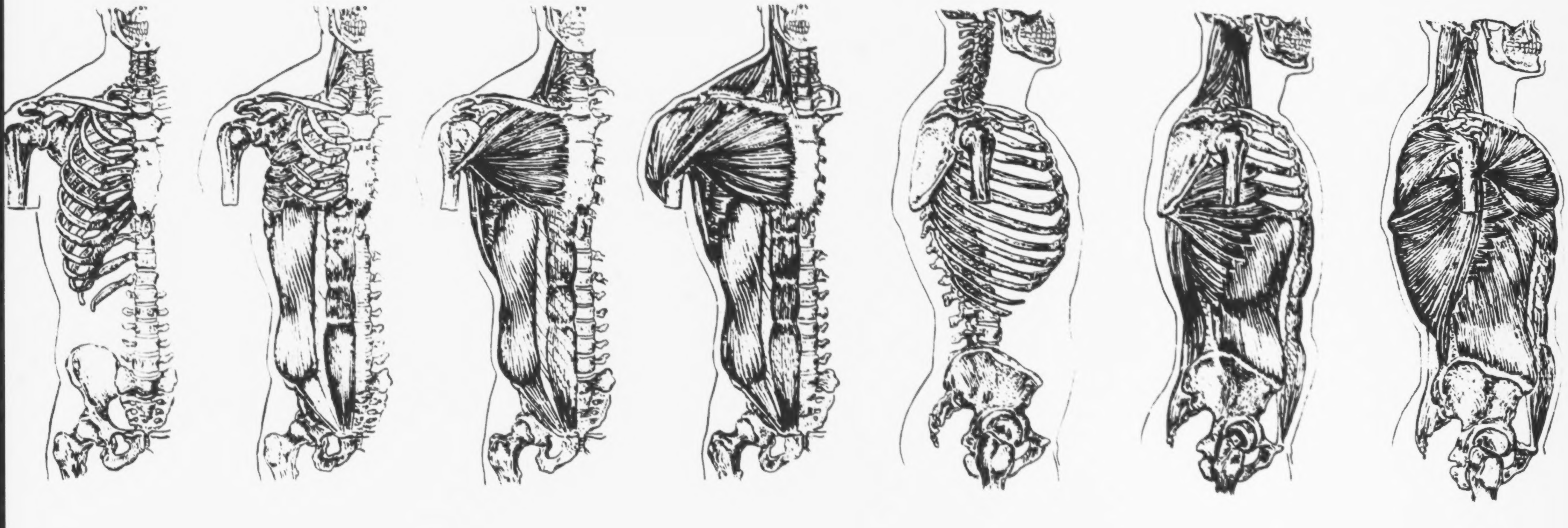


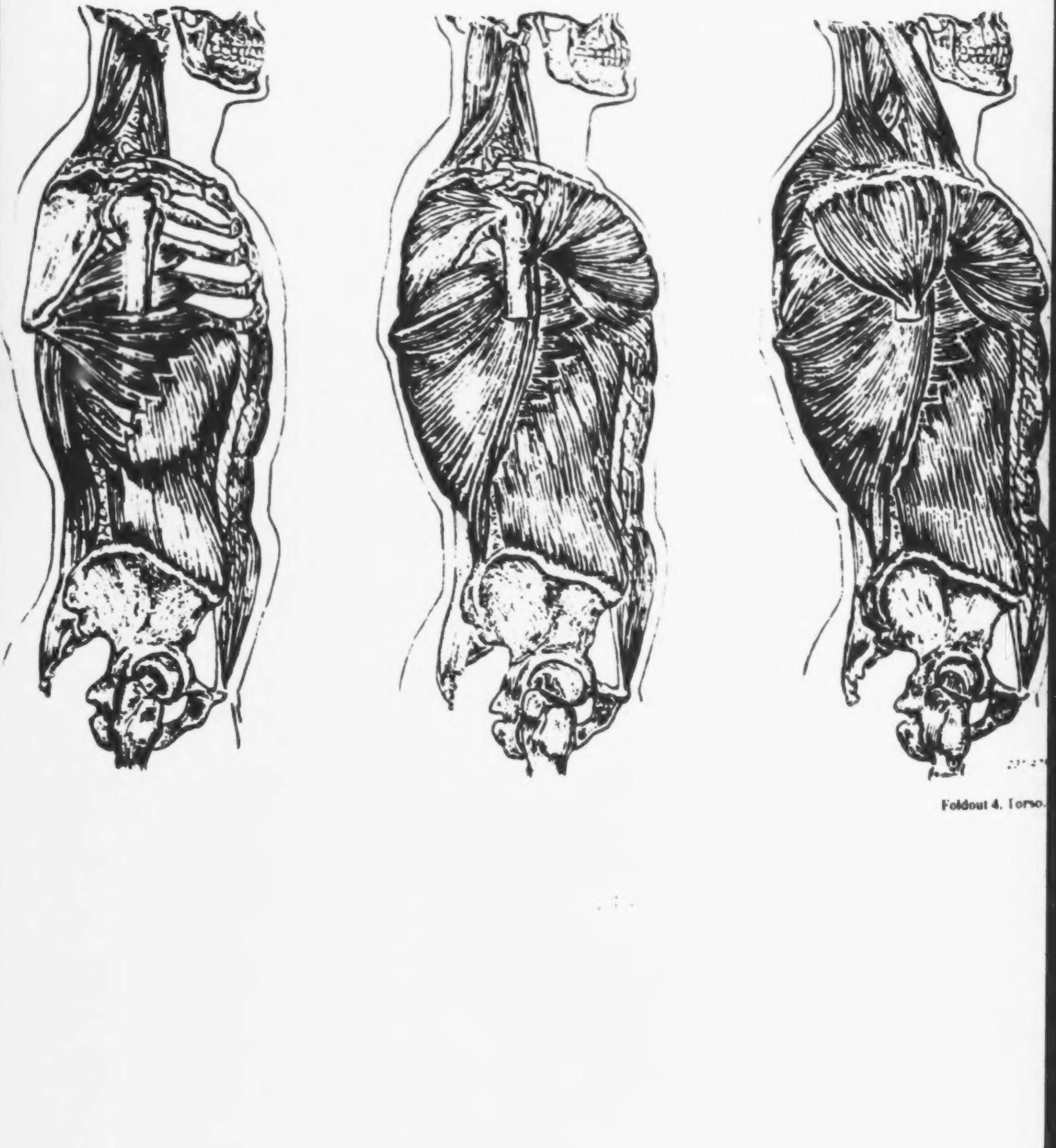
231–509

Foldout 2. Depth, drawing through, light and shade.

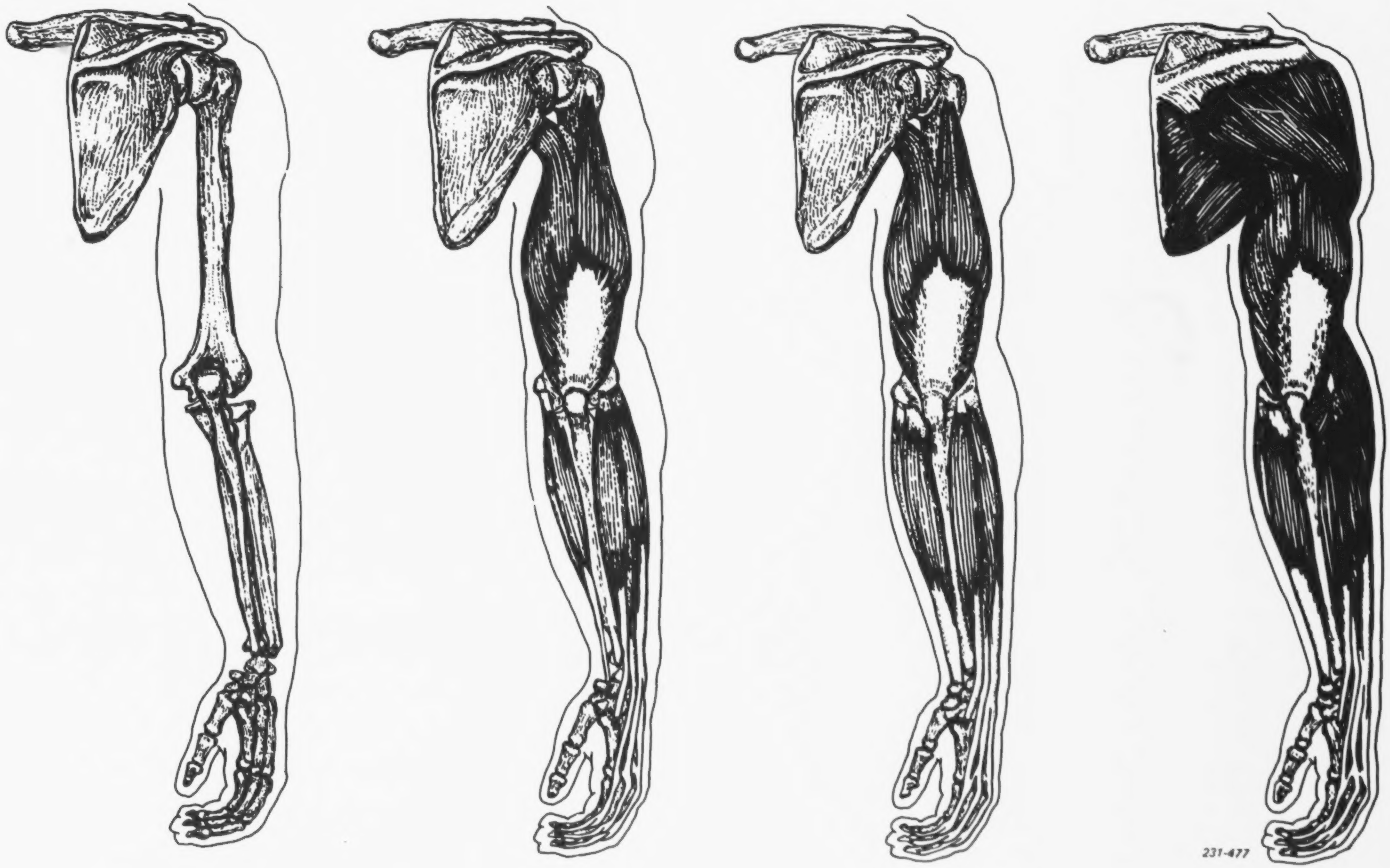


Foldout 3. Male and female figure

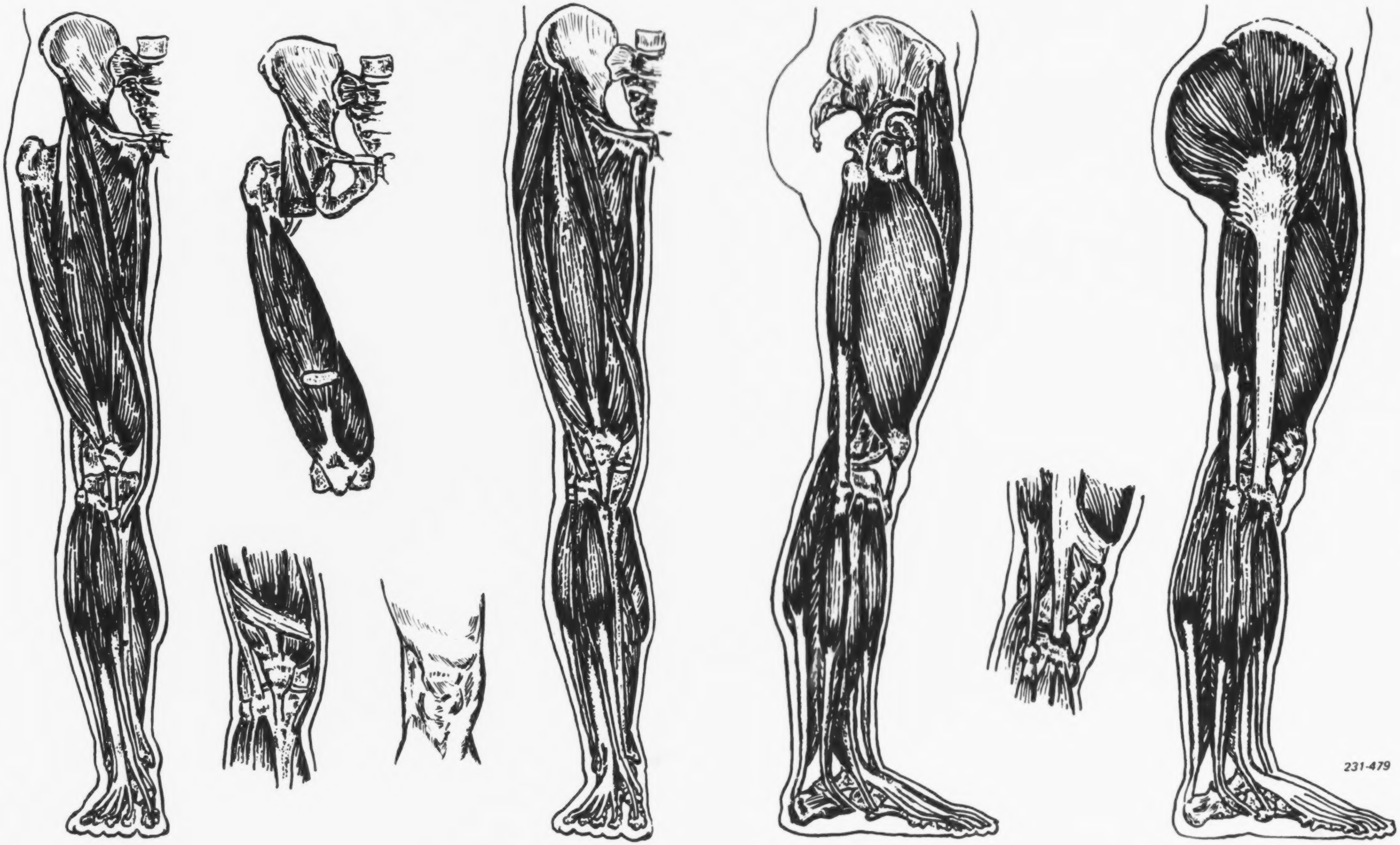




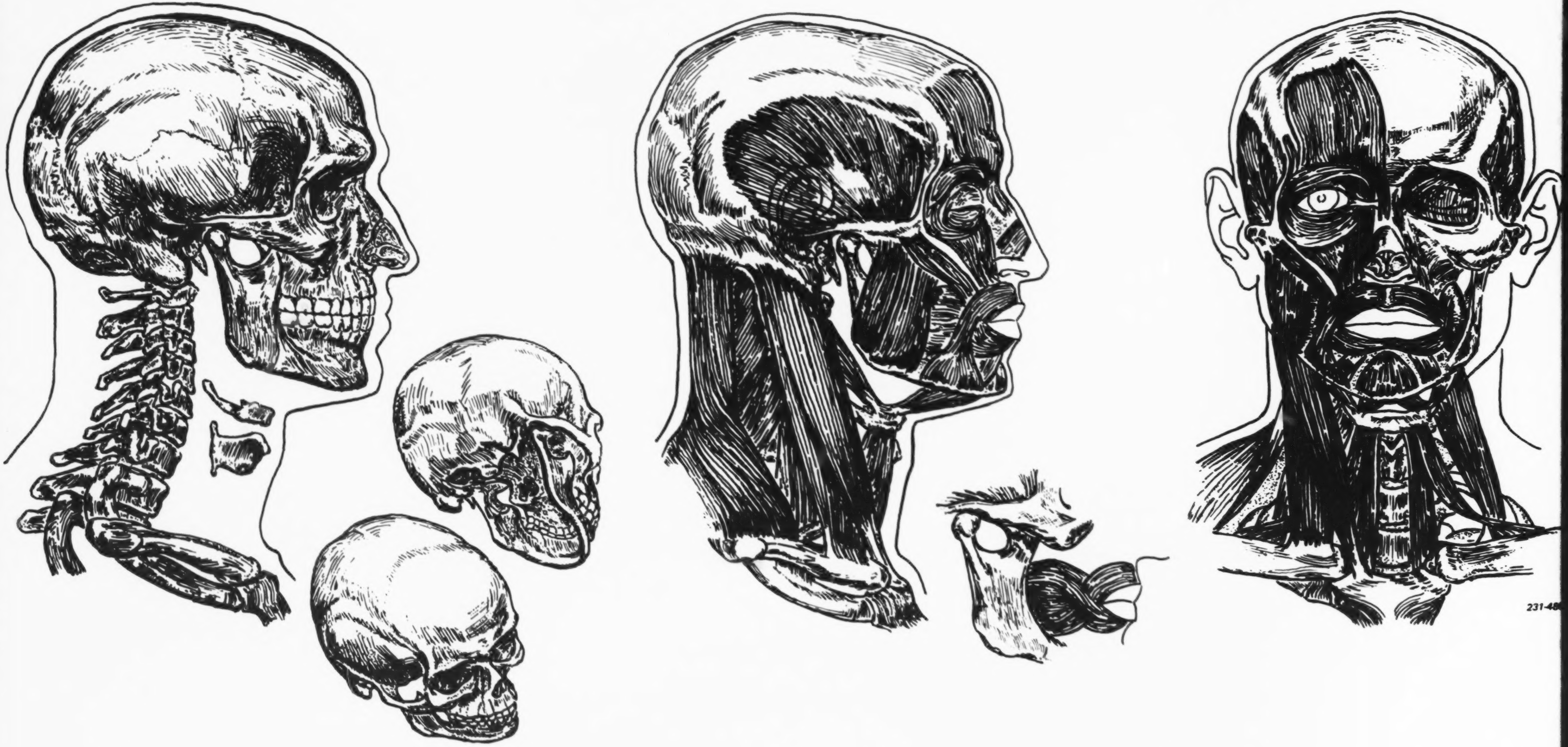
Foldout 4. Torso.



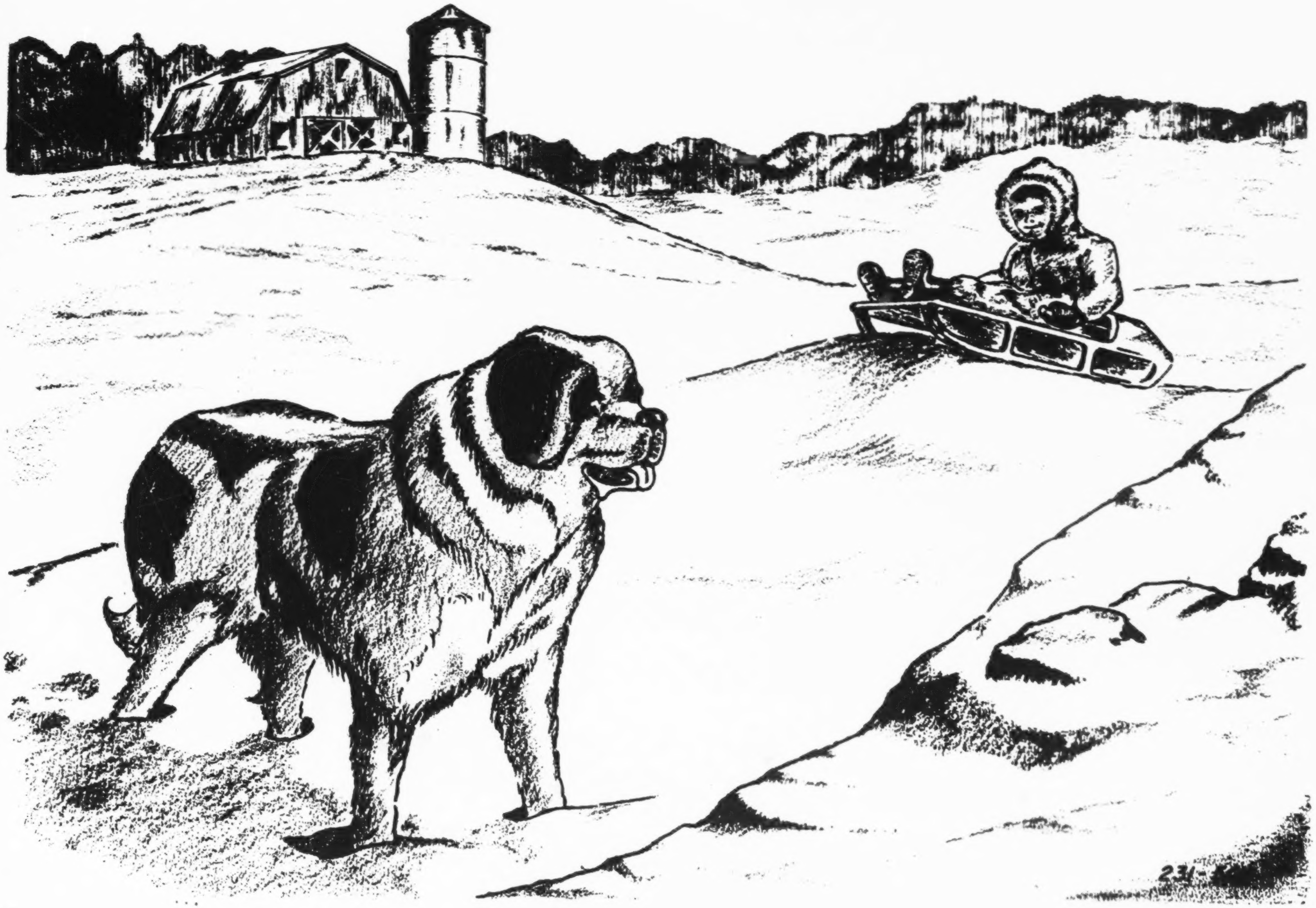
Foldout 5. Arms.



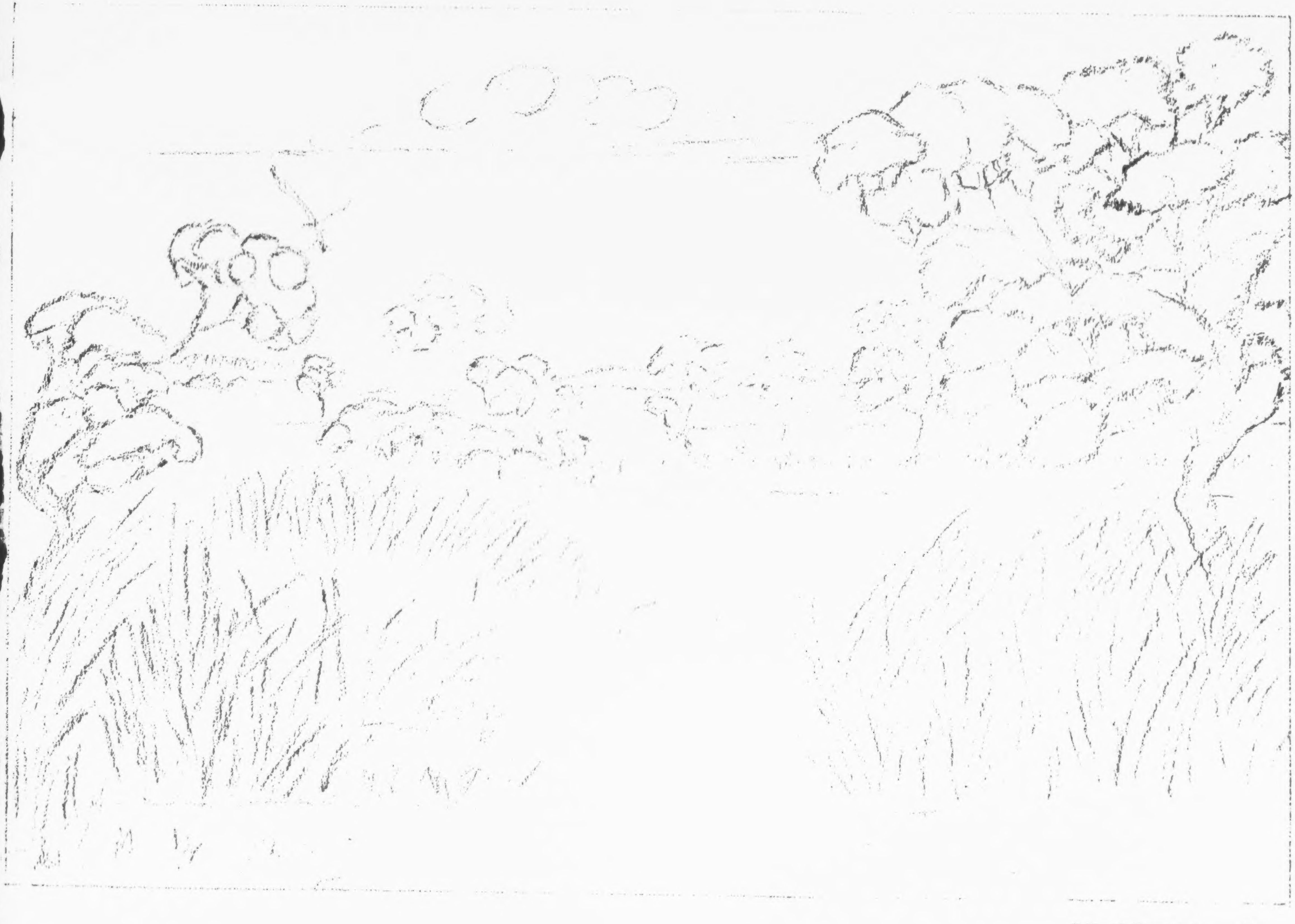
Foldout 6. Leg.



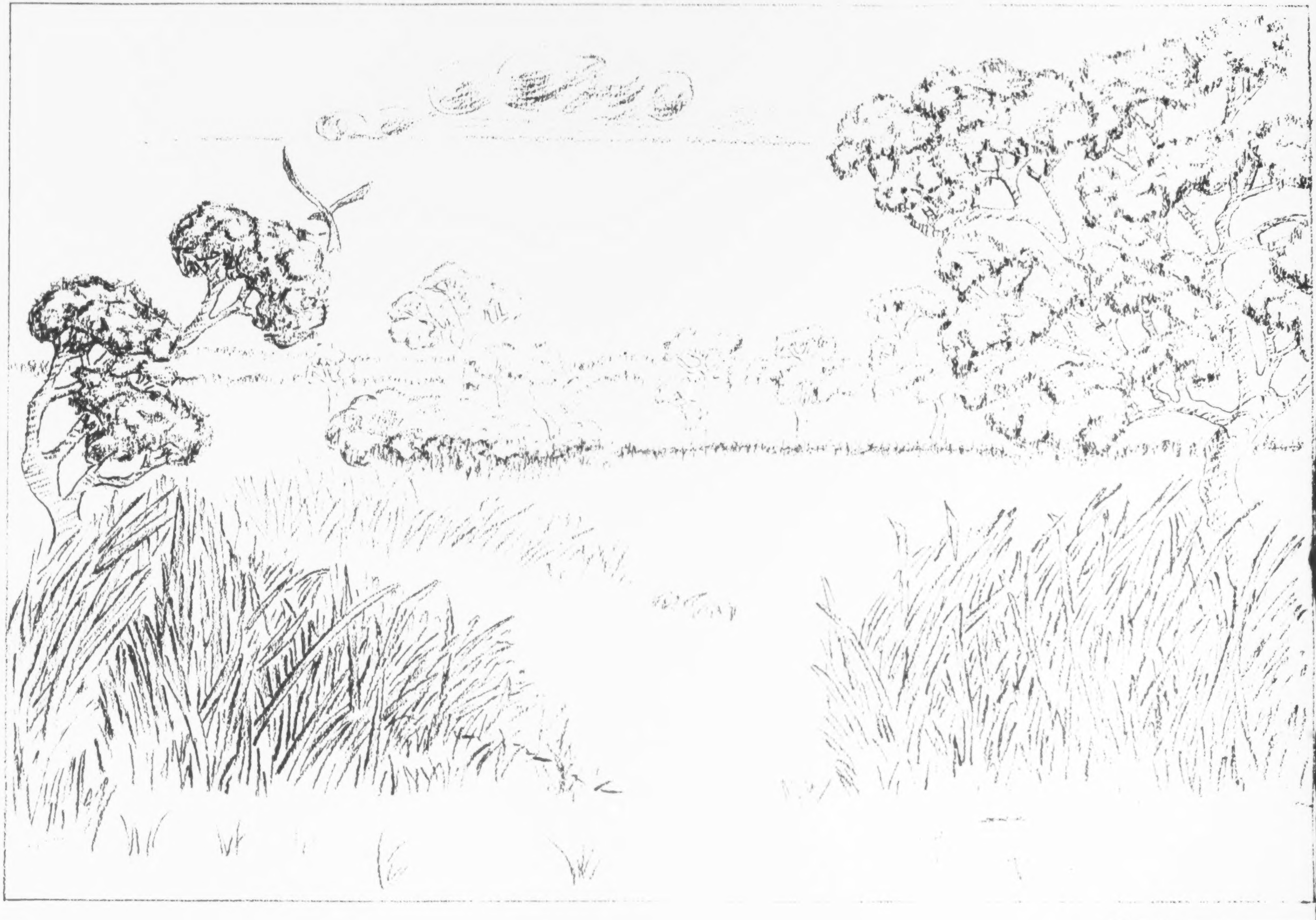
Foldout 7. He



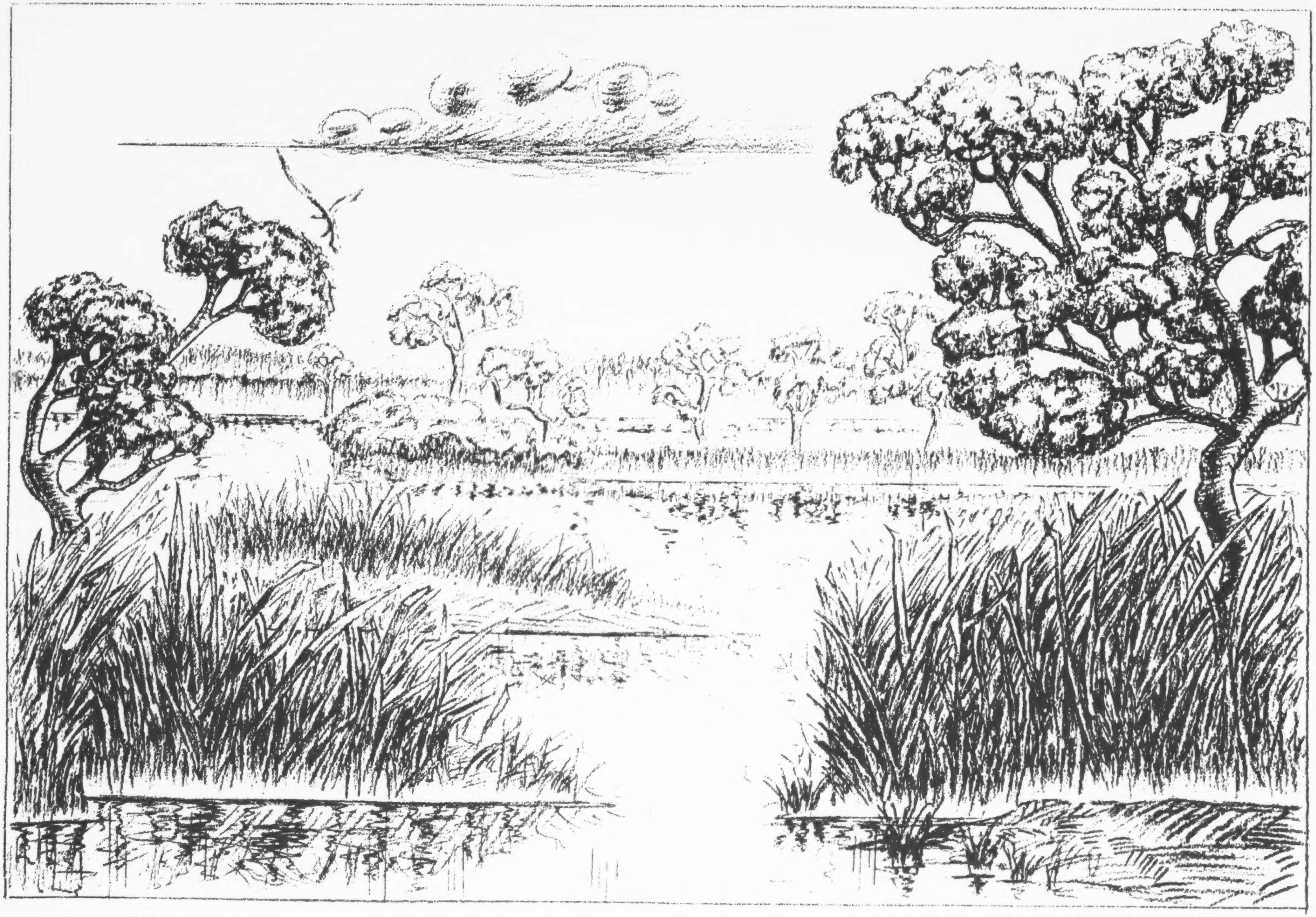
Foldout 8. How to present a thumbnail and rough.



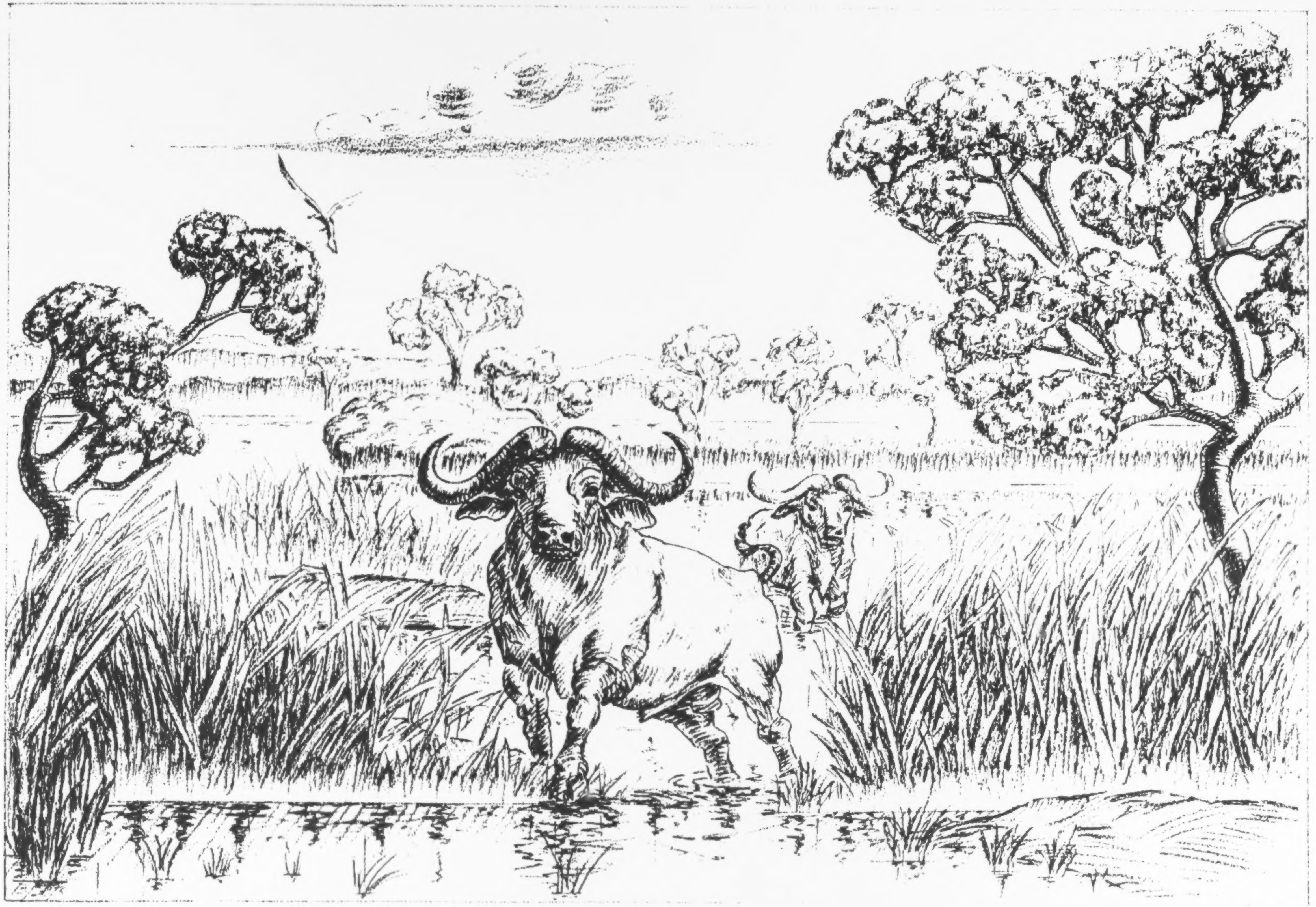
Foldout 9. Element of composition.



Foldout 10. Element of composition.



Foldout 11. Element of composition.



Foldout 12. Principles of composition.

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CDC 23151

GRAPHICS SPECIALIST

(AFSC 23151)

Volume 3

Visual Communications

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Preface

THE INFORMATION in this volume is intended to cover the subject well enough that you will have the necessary background knowledge to carry out your job-related assignments.

The first chapter in this volume contains information on data presentation and charting and their effective uses. The second chapter is on projectual design. Chapter 3 is on printed materials and processes; almost all artwork ends up as a reproduction item in some form or another. Chapter 4 is on special techniques that include airbrushing and silk screen printing. Your job in the Air Force is to produce visual aids so that other people can comprehend complicated subjects simply. We suggest that you study each chapter carefully before proceeding to the next.

Code numbers appearing on figures are for preparing agency identification only.

The inclusion of names of any specific commercial product, commodity, or service in this publication is for information purposes only and does not imply indorsement by the Air Force.

This volume is valued at 12 hours (4 points).

Material in this volume is technically accurate, adequate, and current as of March 1983.

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Visual Communication

AIR FORCE commanders at all levels of command normally have to deal with a great variety of cold, hard facts. For example, the Air Force Chief of Staff must have data that shows the combat readiness of the entire Air Force, and the squadron commander must know which aircraft are ready to fly and how many qualified mechanics and pilots are available to keep them flying. In both cases, the commanders need data (statistics) readily available and so presented that they don't have to spend time reading lengthy, abstract, dry statistical reports. They are not interested in the flood of details that can be put on the printed page. They want facts in a form they can grasp quickly; one that gives them a clear picture of their operation or mission without requiring them to waste their time studying statistics. As an illustrator, you must be able to give this information in well-prepared graphics that communicate visually and that may stand alone or be supplemented with written or spoken words.

Unfortunately, many people are not gifted with the ability to draw rapid and accurate conclusions from a mass of numerical data. Since people usually learn more quickly when facts are illustrated by a picture or series of sketches, a set a good tables, charts, or graphs will make any analysis clearer. Regardless of how the data is presented (table, chart, or graph), the specific medium must be such that it can be easily understood by those for which it is intended; in other words, what best determines whether a table, chart, or graph is used are the people for whom it is designed. Normally, we consider three basic ways in which statistical data and analysis may be presented—narrative, tabular, and graphic presentation. A presentation may be limited to one of these methods, or it may be any combination of them. The data to be presented must be examined carefully, and a method of presentation chosen to highlight the essential elements.

The actual presentation of a chart, table, or graph requires a certain amount of imagination as well as the manual deftness. Since the people (commanders, supervisors, etc.) are usually not artists, they have to turn to someone to help them with the conception of, as well as the preparation of, the proper chart, table, etc. Therefore, as an illustrator, you will be expected to take the figures or data and translate them into simple and understandable graphics. Creating this type of material requires that you understand the possibilities and limitations of the various types of graphics and learn to select the proper type for each particular presentation. Before we go into the actual work of preparing graphics, let's first discuss briefly the methods of presentation (narrative, tabular, and graphic) which may be used.

1-1. Methods of Data Presentation

We previously indicated that there are three basic ways in which datamay be presented; these are narrative, tabular, and graphic. The method of presentation selected is normally determined by the type of data and the intended use of the data. In this respect, there are times when a combination of the styles of presentation may be used to good advantage. For example, material may be presented orally in narrative form; it may be presented orally using charts or other graphics as visual aids; or in the case of this CDC, graphics may be combined with the written word. Let's review some of the advantages and disadvantages of each type of presentation.

400. Differentiate among methods of data presentation by definition.

Narrative Presentation. A narrative presentation may be either written or oral. The information is normally presented in story form, and the text is frequently supplemented by tables, graphs, and charts. There is usually a discussion of the data being considered, and usually there is justification for the conclusions reached. In addition, the narrative presentation may trace the steps of a situation and explain the reasoning behind certain conclusions. From the foregoing you can see that the narrative presentation can take on just about any style necessary to accomplish its intended purpose.

Written Presentation. A written narrative presentation is often used when it is expected that the user will sit down and study the report in detail. In this respect, a narrative report can show a great amount of detail. Studies that are submitted to a higher headquarters or to agencies outside the military service—organizations such as congressional committees, scientific research bodies, or educational institutions—are examples where the written narrative form of data presentation is quite frequently used.

Although the written-type narrative presentation takes advantage of the additional data we can get through seeing, when used alone, this method too has a big disadvantage. A written narrative report containing many numbers or types of data throughout the report is very difficult to use because comparing the data and arriving at a conclusion may be an involved process. Unless you memorize the facts, you must turn first to one page and then to another until a firm picture of the comparative characteristics of these facts forms in your mind. In this particular instance a table could be included along with the narrative, thus making it possible to see all the significant data in one group and to afford an opportunity to make an analysis.

Oral Presentation. Probably the easiest method of delivering a report is by oral presentation. However, it is the least effective and the one most easily forgotten by the audience. Two advantages of the oral presentation are that it gives the preparer the opportunity to present an enormous amount of detail and the chance to answer questions on any point of possible misunderstanding. As a result, the preparer can bring out details that might be overlooked in other forms of presentation.

The advantages of the oral presentation are overshadowed by one big drawback; in an oral presentation the speaker has to rely on one of the least effective learning senses of the human body—hearing. According to some authorities, only 13 percent of what we learn is acquired through the sense of hearing. Contrast this with the fact that we learn 75 percent of what we know through the sense of sight. That is why the oral presentation is considered to be a poor method of presenting statistical data. Considering the amount of work that goes into a statistical study, why waste it by making a report that is only 13 percent effective?

Tabular Presentation. A mass of data sorted, counted, and arranged in a systematic order in the form of a table is called a *tabular presentation*. The particular arrangement of the data into rows and columns depends upon what purpose the table is to serve. All data appearing in a table should be clearly identified, thus eliminating supplementary explanations. It is well to remember that all the user may know is what the table shows.

There are normally two types of tables used in statistical presentations—the *general-purpose table* and the *special-purpose table*. Each type is particularly useful in certain situations. A general-purpose table is designed to present a broad range of data on a specific subject, whereas a special-purpose table is a method for highlighting a particular part of a study. The special-purpose table, in this respect, furnishes specific information about a specific subject. The data for a special-purpose table may be taken from a general-purpose table or from an original source.

While the general-purpose table may be lengthy (and possibly, cumbersome), the special-purpose table is usually brief and to the point. Special-purpose tables are useful for presenting comparisons. Either type of table may be used in conjunction with a chart or graph to show detail that is lost or difficult to observe on the chart alone. Before we go into a few basic rules and concepts of table construction, let's briefly analyze the last method of data presentation to be discussed here—graphic presentation.

Graphic Presentation. Even though tables normally present data in a well-arranged order, the reader or user must still make his own comparisons many times between one bit of information shown and some other information (shown or not shown). Since it is much easier to make comparisons, evaluations, etc., based upon data clearly shown and graphically illustrated, the graphic presentation, either alone or used in conjunction with tabular presentation, is a very effective means of presenting data.

Graphic presentations may be made in many forms and styles. They may be simple or complex in form, as you determine necessary to accomplish the job for which they are intended. The choice of form or style of presentation could well be your responsibility, since the persons who require the data normally states the information needed and expect you, the graphics specialist, to come up with the type of presentation that will best do the job. In this respect, you not only have an obligation, but also an excellent opportunity to demonstrate your effectiveness in your job. Remember, you share an important part in helping the requester make an effective report.

The type of graphic representation used in data presentations depends upon many factors—such as these factors listed below:

- General purpose of the graph or chart.
- Occasion for its use.
- Type of reader (audience) to be reached.
- Nature or amount of data to be presented.
- The significant relationships to be obtained from the graphic.

The list as shown above could no doubt be expanded significantly; however, the factors portrayed should give you some idea of what you must consider to select the type of graphic representation that will do the best job.

Exercises (400):

1. Match the items in column B, with the most appropriate descriptive statement in column A.

	Column A	*Column B*
____ (1)	User will sit down and study details . . . presentation can show great amount of detail . . . is submitted to higher headquarters or agencies outside military service.	a. Hearing.
		b. Narrative containing many numbers or types of data.
		c. Graphic.
		d. Seeing.

Column A

____ (2) Disadvantageous because arriving at a conclusion may be an involved process.

____ (3) Easiest method of delivering report . . . poor method of presenting statistical data . . . presenter can give large amount of detail and at same time answer questions that arise . . . depends on sense of hearing.

____ (4) 13 percent of what we learn.

____ (5) 75 percent of what we know.

____ (6) A mass of data sorted, counted, and arranged in systematic order.

____ (7) Presents a broad range of data on specific subject.

____ (8) Highlights a specific part of study, usually brief and to the point, and useful for presenting comparisons.

____ (9) Helps make comparisons, evaluations, etc., easier . . . used alone or in conjunction with tabular presentations . . . a very effective means of data presentation.

Column B

e. General-purpose table.
f. Tabular presentation.
g. Special-purpose table.
h. Oral presentation.
i. Written presentation.

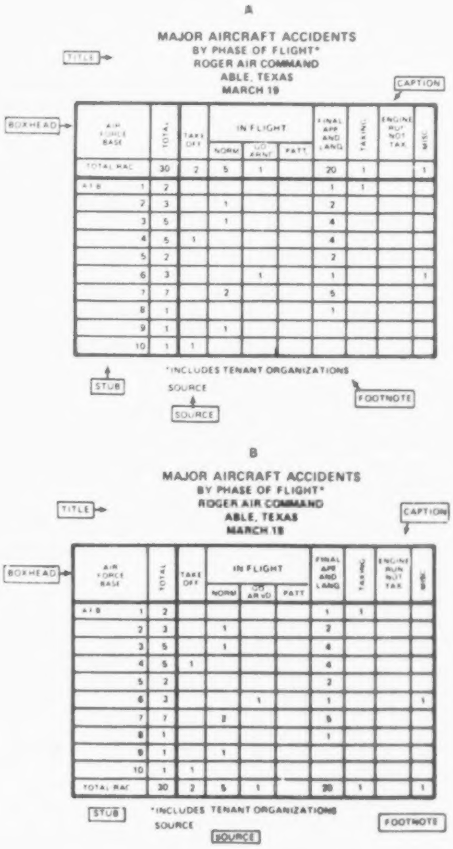
1-2. Graphic Techniques of Data Presentation

As a graphics specialist, it is imperative that you be proficient in the basic techniques of tabular and graphic (charts and graphs) presentation. In the next two major segments of this chapter, we will discuss the construction of tables and the fundamentals of graphic presentation.

401. Cite differences between the methods of tabular presentation and factors to consider in choosing a scale.

Construction of Tables. First, look at some basic points on techniques of table construction. Tables are usually of two general types—general-purpose and special-purpose. Although the construction of either type of table is the same, there are basic differences between the two types.

Figure 1-1 gives examples of general-purpose tables. These type tables present a very broad range of data on a specific subject. In this case, the subject is major


A
TITLE
CAPTION
BOXHEAD
STUB
SOURCE
FOOTNOTE
B
TITLE
CAPTION
BOXHEAD
STUB
SOURCE
FOOTNOTE

A

MAJOR AIRCRAFT ACCIDENTS
BY PHASE OF FLIGHT*
ROGER AIR COMMAND
ABLE, TEXAS
MARCH 19

AIR FORCE BASE	TOTAL	TAKE OFF	IN FLIGHT			FINAL APP AND LAND	TAXIING	ENGINE RUN NOT TAX	MISC
			NORM	GO ARND	PATT				
TOTAL RAC	30	2	5	1		20	1		1
AFB 1	2					1	1		
2	3		1			2			
3	5		1			4			
4	5	1				4			
5	2					2			
6	3			1		1			1
7	7		2			5			
8	1					1			
9	1		1						
10	1	1							

*INCLUDES TENANT ORGANIZATIONS
SOURCE

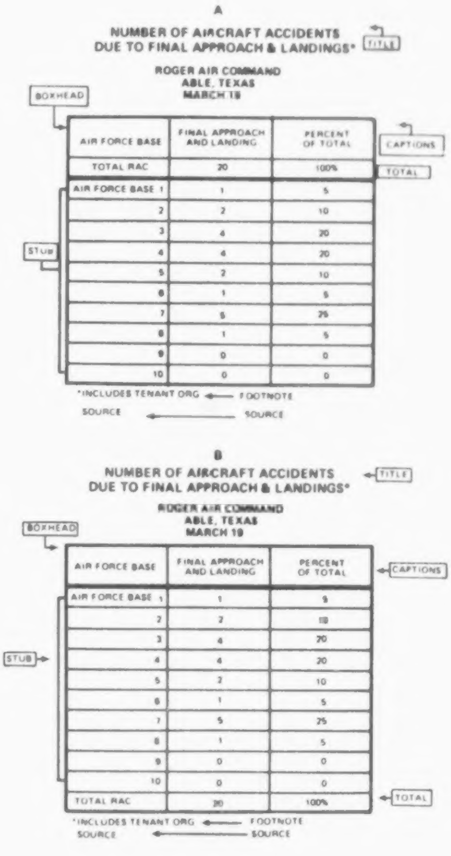
B

MAJOR AIRCRAFT ACCIDENTS
BY PHASE OF FLIGHT*
ROGER AIR COMMAND
ABLE, TEXAS
MARCH 19

AIR FORCE BASE	TOTAL	TAKE OFF	IN FLIGHT			FINAL APP AND LAND	TAXIING	ENGINE RUN NOT TAX	MISC
			NORM	GO ARND	PATT				
AFB 1	2					1	1		
2	3		1			2			
3	5		1			4			
4	5	1				4			
5	2					2			
6	3			1		1			1
7	7		2			5			
8	1					1			
9	1		1						
10	1	1							
TOTAL RAC	30	2	5	1		20	1		1

*INCLUDES TENANT ORGANIZATIONS
SOURCE

Figure 1-1. General-purpose table.


A
TITLE
BOXHEAD
CAPTIONS
TOTAL
STUB
FOOTNOTE
SOURCE
B
TITLE
BOXHEAD
CAPTIONS
STUB
TOTAL
FOOTNOTE
SOURCE

A

NUMBER OF AIRCRAFT ACCIDENTS
DUE TO FINAL APPROACH & LANDINGS*
ROGER AIR COMMAND
ABLE, TEXAS
MARCH 19

AIR FORCE BASE	FINAL APPROACH AND LANDING	PERCENT OF TOTAL
TOTAL RAC	20	100%
AIR FORCE BASE 1	1	5
2	2	10
3	4	20
4	4	20
5	2	10
6	1	5
7	5	25
8	1	5
9	0	0
10	0	0

*INCLUDES TENANT ORG
SOURCE

B

NUMBER OF AIRCRAFT ACCIDENTS
DUE TO FINAL APPROACH & LANDINGS*
ROGER AIR COMMAND
ABLE, TEXAS
MARCH 19

AIR FORCE BASE	FINAL APPROACH AND LANDING	PERCENT OF TOTAL
AIR FORCE BASE 1	1	5
2	2	10
3	4	20
4	4	20
5	2	10
6	1	5
7	5	25
8	1	5
9	0	0
10	0	0
TOTAL RAC	20	100%

*INCLUDES TENANT ORG
SOURCE

Figure 1-2. Special-purpose table.

aircraft accidents (by phase of flight) that occurred within a specific command, in a specific month and year. Further, they cover all the details of interest, giving a complete total and also the totals for a number of bases.

A special-purpose table highlights a particular part of a study. The data may come from a general-purpose table or from an original source. Figure 1-2 gives examples of special-purpose tables developed from the general-purpose tables in figure 1-1. It shows only one of the columns contained in the general-purpose table and presents an analysis in percent. While the general-purpose table is quite long and cumbersome, the special table is usually brief and to the point. The same construction techniques apply to both types of tables.

Good tabular presentations must be planned according to certain standard practices to be effective. Because of the widespread use of tables throughout the Air Force, certain ground rules of format have been adopted. Standardization has many advantages. For instance, when graphics personnel are transferred from one base to another, they have no new techniques of table preparation to learn. Tables developed in one command are easily understood by personnel of other commands. In the next few paragraphs, we will discuss some of the key points in good table preparation.

Title. The title of your table is the first element to be considered. In figures 1-1 and 1-2 good title construction is illustrated. Notice in both of these illustrations that the titles are centered at the top of the table and are in capital (uppercase) letters. The titles, in both cases, are clear and concise. They tell the reader what is being considered as well as where and when the data applies. Under no circumstances should the clarity of a title be sacrificed for brevity. In fact, it is better to use a long title that is complete and clear than to use a short title that leads to uncertainty and confusion. The phrase or phrases of the title should not be broken at the end of a line. Each line should represent a single thought; otherwise, the title is confusing. Just how confusing a title can be is shown by the following example:

MAJOR AIRCRAFT
ACCIDENTS BY PHASE
OF FLIGHT

Compare this title with the correctly arranged title in figure 1-1.

Organization of the body. The organization of the body of the table is just as important as the arrangement of the title of the table. A table must present data simply and clearly. Arrange your data in a systematic form that emphasizes the important items contained in the table. Since we read from left to right and from top to bottom, the upper left portion of the table is the choice spot for the most important factors of the table. Notice in figure 1-1 that the totals are placed in this portion of the table since this data is one of the important factors for this particular table. In other situations, showing totals at the bottom of the table is a perfectly acceptable procedure.

There are several ways to arrange the items in the body of a table. They may be arranged alphabetically, geographically, chronologically, or in some other logical order, depending upon the intended use of the table and the data to be presented. If an alphabetical arrangement is used, the order of presentation should be by subject. If geographicsl or chronological presentations are used, the order of presentation or table arrangement must be determined by other means. For example, a geographical arrangement could be by size, using either ascending or descending magnitude; a chronological presentation could be arranged by order of natural interest, by order of the emphasis desired, or by some customary classification (such as airmen, officers, male and female adults, children, etc.). Regardless of the type of presentation (alphabetical, chronological, etc.), you must decide on the arrangement of the data before you can construct the rest of the table. With the arrangement of the data decided upon, list the items across the top of the table or down the left side in the order of their importance.

Each major element of the body of a table has a name, as indicated in figures 1-1 and 1-2. They are:

a. Columns—the term for vertical listings.

b. Rows—the term for horizontal listings.

c. Boxhead—contains the captions (titles) of the vertical columns.

d. Captions—must describe clearly the data (information) in the columns.

e. Stubs—usually the extreme left-hand column.

f. Stub Items—titles appearing in the stub.

As we discuss these elements of the body, refer to the tables in figures 1-1 and 1-2 for their location.

Captions. Captions, generally speaking, are also related to the title of the table. In figure 1-1, the title indicates that the table is about major aircraft accidents, so it is logical to assume that the captions in the boxhead will show different types (or causes) of aircraft accidents. In this case, it would be an error in construction to list the various Air Force bases in the boxhead and to show the types of accidents in the left-hand column, because the table title would not then be in agreement with the captions or vice versa.

Because of the relationship between the table title and the captions, if the title is detailed, the captions may be brief. If the title is general, the captions should be sufficiently detailed to eliminate any possible misunderstanding.

The captions in a table should also contain the unit of measurement if that unit is not adequately indicated in the title. In figures 1-1 and 1-2, the unit of measurement is obviously a number, but, in some tables, the units of measurement (such as dollars, percent, miles, gallons, and hours) must be shown in the caption. This unit identification is especially needed if the various columns show different kinds of information. For example, one column may show gallons of gasoline; the next, miles per gallon; third, cost in dollars. In such cases, you can see that the captions must contain the unit of measurement for the table to be understandable.

The stub should contain a title for each horizontal row in the table. The stub items are usually listed in some order, such as numerical, alphabetical, or geographics. They should be clear and complete enough to prevent any misunderstanding. Notice in figures 1-1 and 1-2 that the stub items are listed numerically.

Footnotes. Footnotes are used to clarify items in the table that are not completely self-explanatory or that contain information or data not usually considered as pertaining to the item. If you cannot print an adequate caption in the space available, you can clarify it in a footnote. Also, use footnotes if there is not sufficient space to clarify a stub item properly.

The reader's attention is usually directed to a footnote by an asterisk (*) or some other graphic symbol. Never use one symbol to identify two different footnotes. If a footnote applies to more than one entry, however, place its symbol after each entry to which the footnote applies. Avoid using small numbers to indicate footnotes pertaining to numbers. These small numbers may be mistaken for exponents, subscripts, etc.

Usually, you can depend upon the saying, "If data can be misinterpreted, someone will misinterpret it." Therefore, if you have any doubt about the clarity of any item, remove that doubt with a footnote. On the other hand, the overuse of footnotes is not advisable. If there are three or four footnotes on a table is usually means that it is time to examine the table and data to find out why so many footnotes are needed. Perhaps the trouble is a poor selection of captions or stub items. Perhaps if you rearrange the data, you can make a better table. At the very least, you need to recheck your table very carefully to discover a better way to present the data. Remember that the purpose of a table is to present data clearly and concisely.

Source and preparation. For a table to be complete and effective, it must indicate the source of the material it contains. This should be included with the draft information furnished to you for the preparation of the table. It is standard practice to show the source of the data in the lower left-hand corner of the table. Place the source statement below the footnote (if there is a footnote) on the table. In some cases, it is also desirable to show the preparing agency and the data of preparation. Place this information at the bottom of the table near the source of information. On charts, the preparing agency and data are usually shown at the lower right. On tables, no specific location is designated.

Division of table components. There are a few general rules to follow in dividing a tble into its components. Separate your boxhead and stub from the main body by double lines or a very heavy single line. Separate columns and rows by single lines. If you are not using lines, indicate the divisions by the size of the space left between your entries. Using space to separate columns is a frequent practice when tables are prepared on a typewriter. When the captions are major groupings with subdivisions, separate the major group by double lines or narrow spaces. Use rulings or spacings to group items so that the eye will automatically pick out the ones that are closely related. Rulings make it easy for the reader to follow the trend of thought of the preparer when he selected the table design.

Table layout selection. You will find it difficult to visualize the proposed table and plan the size of lettering, width of spaces, and overall size without first making a sketch. You may need several rough sketches in order to select the layout that meets every need. By trying different layout arrangements, you can emphasize various aspects of the data or bring an assortment of facts into a position where they can be compared readily. When you are experimenting with different arrangements, you will find that two series can be compared best if they are in adjoiing columns, and that totals are emphasized when they are placed at the upper left of the table. In fact, it is just a recent trend in the Air force to locate the totals at the top left rather than at the bottom. This makes it possible for the reader to grasp the conclusion of the study without having to search it out.

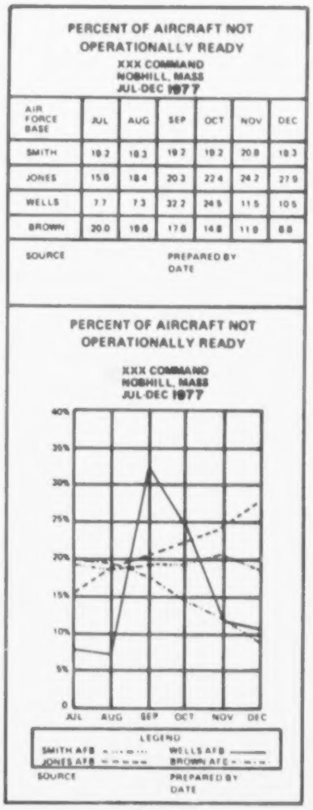
Summary. In brief, in table construction you must remember certain basic facts:

a. First, know exactly what facts are to be presented.

b. Know what contrasts or comparisons must be made.

c. Know the specific point of interest of the persons for whom the table is prepared.

d. Know and employ the proper techniques of table preparation.



PERCENT OF AIRCRAFT NOT
OPERATIONALLY READY
XXX COMMAND
NOBHILL, MASS
JUL-DEC 1977

AIR FORCE BASE	JUL	AUG	SEP	OCT	NOV	DEC
SMITH	19.2	18.3	19.2	19.2	20.8	18.3
JONES	15.8	18.4	20.3	22.4	24.2	27.9
WELLS	7.7	7.3	32.2	24.5	11.5	10.5
BROWN	20.0	19.6	17.6	14.8	11.9	8.8

SOURCE
PREPARED BY
DATE

Figure 1-3. Graphic presentation of data.

Fundamentals of Graphic Presentations. Even though good tables present well-arranged data, the reader or viewer must still make comparisons between one piece of information and another. Only in this way can the user analyze and evaluate the information for the identification of possible problem areas and solutions. In the Air Force, AF commanders and/or supervisors often need essential data quickly. They should be able to grasp the main facts without searching through a mass of detailed information. To provide this support, well-designed statistical reports, accompanied by your effective charts and graphs, highlight essential informative data. Regardless of the level of command, well constructed graphs and charts are two of the best methods of effective data presentation.

Consider the data presented in the two parts of figure 1-3. They present the same data. The upper half of figure 1-3 lists the bases of a command with the percentage of aircraft that were not operationally ready for each month of the past 6-month period. By studying the data closely, you can see that Brown Air Force Base has been having fewer and fewer aircraft operationally ready each month. Further study shows that Jones Air Force Base, on the other hand, has been steadily improving in its percentage of aircraft ready.

Now glance at the lower half of figure 1-3. Just a glance is all you need to tell you, or the commander, the same story about these two bases. Going back to the upper half of figure 1-3, look at Wells Air Force Base. You probably didn't notice the change in the month of September in percentage of aircraft not ready. (That month a storm caught some aircraft on the ground causing damage that required many days to repair.) Yet this increase in not-ready aircraft is instantly apparent in the lower half of figure 1-3. See how much more quickly you get the same ideas or information from the graph than the table. You might even say one graph or chart is worth a thousand numbers neatly arranged in tables because the graph instantly shows the relationship of the data elements.

However, one picture can replace many words or numbers only if the form of its presentation is carefully selected. There are many different forms in which data can be presented graphically. We will discuss the various forms of charts and graphs later in this chapter. As we discuss each form, we will note its advantages and disadvantages. It is very important that you learn to select the graphic form that most effectively presents your data. Before we take up each of the many different charts and graphs, there are a few basic principles of graphic layout, equipment, and material that you should review.

Equipment and material. Basic drawing equipment and materials are, of course, required in the production of good graphs and charts. The alert graphics specialist should have access to all the latest materials, methods, and techniques—especially those that speed up and simplify the job. Since many of the tools and materials that are used in the preparation of tables, charts, graphs, etc., are used in the graphics artwork discussed in the first volume of this CDC, we will elaborate only on those that are peculiar to graphic chart work.

Among the important aids to graphic production are parallel-ruling units, leroy reservoir and rapidograph pens, speedball pens of many styles, the airbrush, lettering guides, mechanical lettering sets, and enlarging and reducing projectors. For your work, you may use pastels, crayons, colored pencils, and various colored drawing inks. Your selection of tools and materials to use in preparation of a chart or graph should be based, to some extent, on the use and life of the chart. Consider how it will be maintained and updated, and, possibly, your preference in filling the requirements of the requestor. Selecting the proper tools and materials can make your work easier, faster, and undoubtedly better. You wouldn't prepare an elaborate chart for a short briefing; neither would it be wise to prepare a pencil-drawn chart on a monthly or yearly chart program for the commander.

Frehand lettering, if of good character, is acceptable for graph and chart work. If you have difficulty making good freehand lettering, you will find one of the mechanical lettering devices useful. Most of the lettering in the illustrations of this volume was made with a lettering set.

Probably the most useful of the materials available to the graphics specialist for making graphs and charts is the acetate or cellophane overlay material with an adhesive backing. These overlay sheets are made in a variety of types, faces, symbols, colors, and patterns. The adhesive backing enables you to apply the material directly to the graphic with a burnishing tool (a piece of plastic such as the back of a pocket comb). Overlay material is usually available with either a paraffin backing or a heat-resistant adhesive. If graphs or charts are to be reproduced by the diazo method, use the heat-resistant type because of the heat generated by the process. The paraffin-base material would melt and ruin the entire graph or chart. The paraffin-backed material is more economical and should be used if the graphic will not be subjected to temperatures above 110° F.

The coding of your graphs can be done with much more speed and ease when you use the overlay materials, such as acetone or cellophane. The variety of patterns and colors help you create special effects suitable for graphic presentations. You place the overlay material over the area to be shaded or colored, and press it into place. Trim off the excess by lightly tracing the outline of the area with a sharp razor blade or knife, and then gently pull the excess from the surface of the chart. Complete all pen and ink work on your graph or chart before you apply the overlays to the work.

Graphic layout. Almost any statistical analysis can be presented graphically. The possible variations in design are almost endless and depend to a great degree upon the imagination of the analyst/requestor and the graphics specialist who designs the chart. The type of chart or graph used to illustrate the important parts of a study may make the difference between the success and failure of the analysis.

The value of a good graph or chart lies in the fact that we obtain 75 percent of our knowledge through the sense of sight. Figures may be quoted orally for hours, and in all probability the listeners will forget most of them. But, shown a simple picture of the same data at a briefing or meeting, the viewers will probably retain it for some time. Cold facts, when presented numerically, remain unnoticed unless the reader's attention is focused on them by some special means.

A well-prepared chart presents a clear picture, but the scope of the data presented should be limited. Overcrowding data obscures the main point of a chart, often defeating the primary requirement of a good chart—easy reading. Two or three charts with one or two ideas on each are better than one chart with six ideas, some of which are obscured.

A good chart is attractive but not gaudy. If colors are used, they should be harmonious and not too numerous. Colors are especially useful in highlighting important factors on the chart, but if they are too gaudy and too many colors are used, they become the important factors and the really important data is lost.

It is imperative that the data portrayed on charts be accurate, timely, and clear. Charts are of great value in helping a reader arrive at conclusions, but they cannot take the place of careful study of a problem. A chart is a means to an end and not an end in itself.

Just as in the case of tables, there are some preliminary plans to be made and some basic rules to follow in chart development. Your planning includes recognizing the point of view of the reader, selecting the type and size of chart, arranging the items, considering the essential use to which the chart will be put, and, most important, selecting the portion of the study to highlight. Considering the point of view of the requestor should not be difficult. In most isntances, you produce charts for a commander, staff officer, or first line supervisor. The requestor briefs you on the purpose of the chart, the type of briefing or meeting where it will be used, and the people who will see it. Frequently, the requestor specifies the type and overall size of the chart desired. In most cases the individuals who are requesting graphic artwork realize that you are the specialist and ask your opinion or leave the entire project in your hands.

Every Air Force chart should conform to a few basic ground rules, regardless of the type of chart. Figure 1-4 illustrates the essentials to follow.

a. Title—Follows the same rules as does the title for a table, and tells, in brief and specific terms, the what, where, and when.

b. Scale or Range of Values—Listed on the left side of the chart or graph, it shows the unit of measurement and numbers. The scale caption must be shown also.

c. Items Being Charted—Identified at the bottom of the body of the chart, these items may be such matters as aircraft, months, Air Force bases, etc. The name of each item is centered immediately below the line or space where its value is plotted. If more specific values than can be read from the chart are desired, these values may be placed under the name of the item.

d. Legend—Identifies the data plotted on your chart or graph; the more types or trends of data on a chart, the more essential your legend is. The different types or trends of data shown on a chart or graph need distinguishing markings so that the viewer can compare the items presented. In legend block you associate each mark with a particular type or trend or data. For examkple, a line chart, showing the monthly cost of operating a base, may show four types of data relating to cost: a total cost line, payroll cost line, cost of supplies line, and miscellaneous cost line. You may differentiate these lines by dashes, dots, solid lines, colors, or a combination of them so your viewer can accurately distinguish the different types of data shown. Your legend block usually goes in the lower right corner of the chart. Locate it within the body of the chart itself when possible. If, as in some cases, data has to be shown in that area, place the legend block below the body of the chart on the right-hand side or in some other convenient location.

e. Source Data—Located in the lower left of your chart, as in a table. Indicating the source of your data is esential. Without it your chart loses validity.

f. Preparation Information—Shows the data and the agency (OPR) that requested the chart. Give the preparation date and the prepared-by element (probably the requestor's office symbol or title) in the lower right-hand corner of the chart.

Choosing a Scale. The proper selection of a scale is imperative in the construction of graphs and charts. Without the proper scale, the most elaborate chart can be ineffective because its construction is out of proportion, it loses eye appeal, and more important, it gives the wrong impression of the data to its viewers. As we have recommended in tabular construction, rough drafts are highly desirable for planning puposes and essential in the planning of charts. Scales are especially difficult to design if you haven't tried them out on rough sketches. Usually, scales start in the lower left-hand corner. The vertical lines are normally reserved for plotting items. The horizontal lines are arranged along the left-hand vertical lines.

One of the first things to consider in selecting a scale is the range of values. The lowest line on a chart is almost always zero. This means that the larger the range of values, the taller the finished chart will be. Since many statistical charts show financial conditions, we **shall use dollars as our example in determining the scale of a chart that is to show the cost of operating an** Air Force base. Assume that the highest cost for operating the Air Force base for 1 month is $3,500,000. Good chart design (except for percentage surface charts) requires that the top line exceed the highest value anticipated by a sufficient margin to leave a blank space between the largest value to be plotted and the top line of the chart. Since even numbers are more rapidly grasped than odd numbers, let the top line represent 4,000,000. So, actually, the range line of your scale is $0 to $4,000,000.

Since it would be practically impossible to design a chart with four million horizontal lines, each

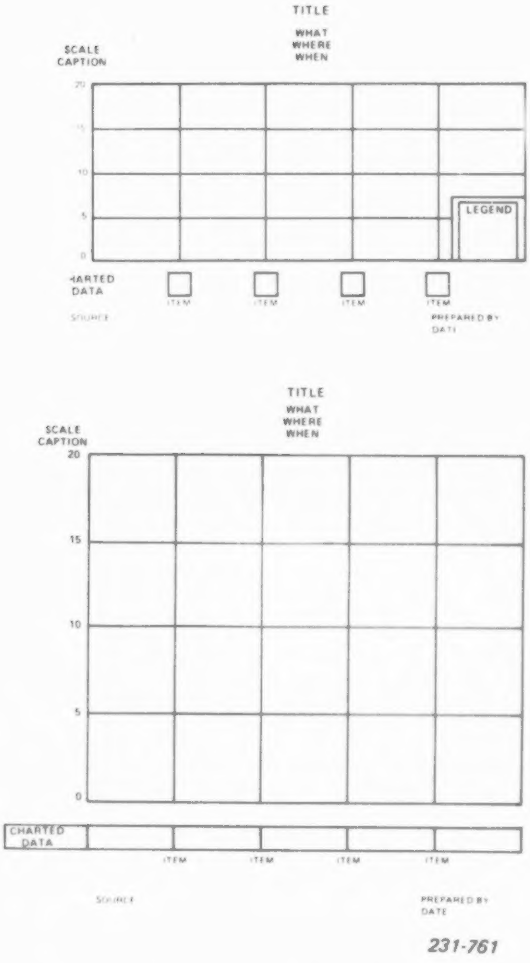

TITLE
WHAT
WHERE
WHEN
SCALE
CAPTION
20
15
10
5
0
LEGEND
HARTED
DATA
ITEM
ITEM
ITEM
ITEM
SOURCE
PREPARED BY
DATE
TITLE
WHAT
WHERE
WHEN
SCALE
CAPTION
20
15
10
5
0
CHARTED
DATA
ITEM
ITEM
ITEM
ITEM
SOURCE
PREPARED BY
DATE
231-761

Figure 1-4. General format for graphs and charts.

representing a dollar (also very needless), you must compress the scale to some convenient multiple of dollars. To do this, examine the data to be charted and find the most helpful intervals to use. You will find that intervals of $250,000 are very convenient (any other values within reason could be selected depending upon dollar breakout desired). If you use $250,000 as the major interval on the scale, you need 17 horizontal lines ($4,000,000 - $250,000 = 16, plus 1 for the zero line = 17).

At this point, you must plan the size of the chart. It is much easier to let the size of the scale dictate the height of the chart than it is to try to fit the scale into a predetermined height. If you let 1 inch (25.4mm) equal $250,000, then the height of the chart will be 16 inches (406.4mm) (not counting the title, legend, source, etc.). If you had already decided to have a chart 15 inches (381.0mm high, then 0.9375 inches (23.8mm) or 15/16 inch would represent $250,000, and you would probably have a measurement problem. You can see that unless the overall physical size of the charts needs to be smaller

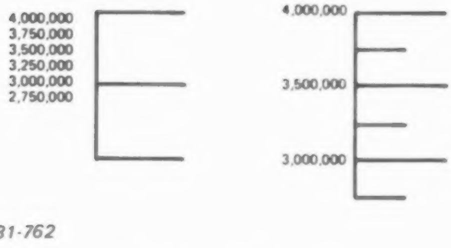

4,000,000
3,750,000
3,500,000
3,250,000
3,000,000
2,750,000
4,000,000
3,500,000
3,000,000
231-762

Figure 1-5. Choosing a scale.

because of its intended use, using the 1-inch (25.4mm) scale will certainly make the job much simpler and, therefore, faster.

You have decided to use intervals of $250,000 for each vertical inch on the chart. It is now time to examine the horizontal lines. They serve, you'll recall, two purposes—they help you plot the data and they help the reader assign a value to each plotted point. By making a rought draft of the chart, you can find out whether the reader needs lines at intervals of $250,000. Perhaps the values of the data make it more advisable to have heavy horizontal guidelines at intervals of $500,000 instead. The two choices are partly contrasted in figure 1-5. As you can see, the chart on the right of the figure can be more quickly and easily read.

A glance tells you that the $500,000 interval is much easier to read. The intermediate lines at the $250,000 intervals help the reader evaluate the data plotted between any two horizontal lines, and, of course, these lines must be there if you follow your $250,000 interval scale.

The point(s) to be learned from this little discussion are these: use only as many guidelines as are needed for a quick comprehension of the values charted; the more heavy lines there are, the more confusing the chart

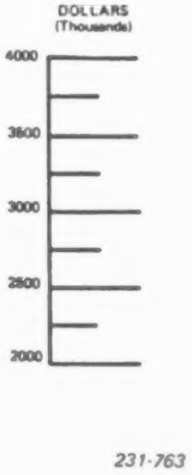
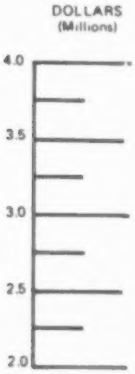

DOLLARS
(Thousands)
4000
3500
3000
2500
2000
231-763

Figure 1-6. Dollars in thousands.



231-764

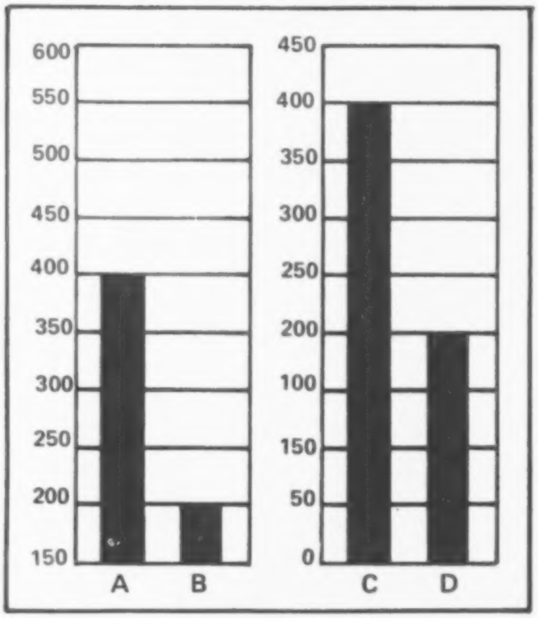
Figure 1-7. Dollars in millions.

becomes. On the other hand, if the critical values are not indicated by a sufficient number of guidelines, the reader has difficulty in assigning values to the plotted data.

Return to the scale in figure 1-5. If you look at the distribution of values along the scale, you notice at once that it is cluttered up by zeros which add length to the values. The zeros also take up space that could be used in the body of the chart itself, and they add work for the graphics specialist. You can eliminate many of these zeros if you show them in another way in the scale caption. If you head the scale as "Dollars (thousands)," as shown in figure 1-6 you can eliminate the last three zeros from each value. The scale is now more easily read and is almost as easily understood. You can further improve (and it is even more easily understood), by giving it in millions of dollars, as shown in figure 1-7. This is probably the best scale to use because the reader does not have to convert the three thousand five hundred, etc., mentally into three million five hundred thousand, etc. You will find examples of the effectiveness of this method of compressing scales in other figures in this section.

Normally, scales should always start at zero. Although you may save a few cents worth of drawing board by starting part way up the range of values, you usually mislead your reader by doing so. You do not show the entire range of values when you start at some intermediate point. You also can create a false impression if you show data on a bar chart in this manner. Figure 1-8 illustrates how misleading a conclusion can be when it is drawn from a chart that starts above the zero value.

In the chart on the left in figure 1-8, column A appears to be five times the value of column B. Column B gives the impression of representing a very small quantity as compared with quite a large quantity for column A. In the chart on the right in figure 1-8, column C appears to be twice as high as column D, and, in fact, it is. Column D appears to represent quite a few items, and it does—200 in fact.



POOR SELECTION OF
SCALE DECEIVES THE
READER

231-765

Figure 1-8.

The facts in figure 1-8 are that column A and column C each represents 400 items and column B and column D each represents 200 items. When 200 is compared to 400 on a well-prepared chart with its values starting at zero, the true relationship between them is readily apparent (right side of fig. 1-8). If 200 and 200 are compared on a chart with its values starting at 150, the true relationship is lost, viewers get a distorted picture of the data. The fact that the scale is there to be read does not lessen the deception conveyed by the chart on the left.

Another device to avoid is the split scale. This scale is usually divided somewhere toward the upper end and is resumed after a part of the values have been omitted. This device is sometimes used when the range of values is large. You can avoid it by using a more cleverly designed scale. Figure 1-9 shows how split scales give a false impression.

In the chart on the left in figure 1-9, column B does not appear to be three times the value of column A because the scale jumps from 80 to 200. All of the 80 items are shown in column A, but 120 items are missing from column B. In the chart on the right in figure 1-9, you get the correct impression because column D is actually three times as high as column C. Column A compared with column B does not give the correct impression.

The intervals you select for your scale should be directly related to the data you are going to chart. The

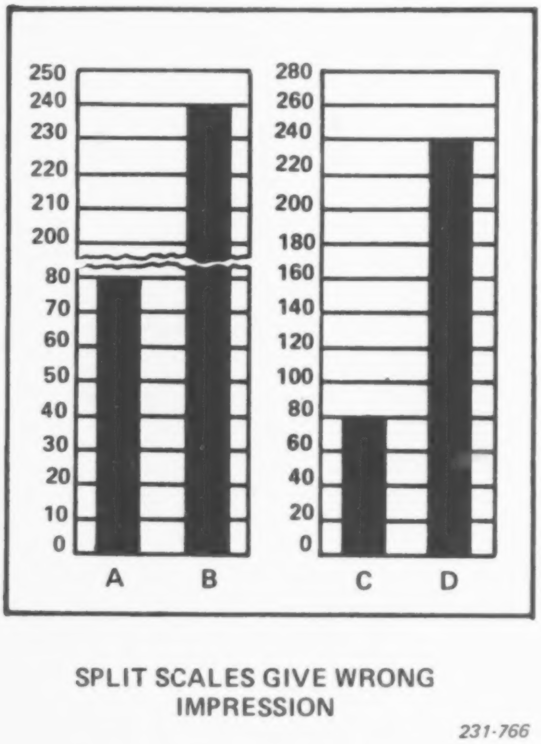


Figure 1-9. Split scales give false impressions.

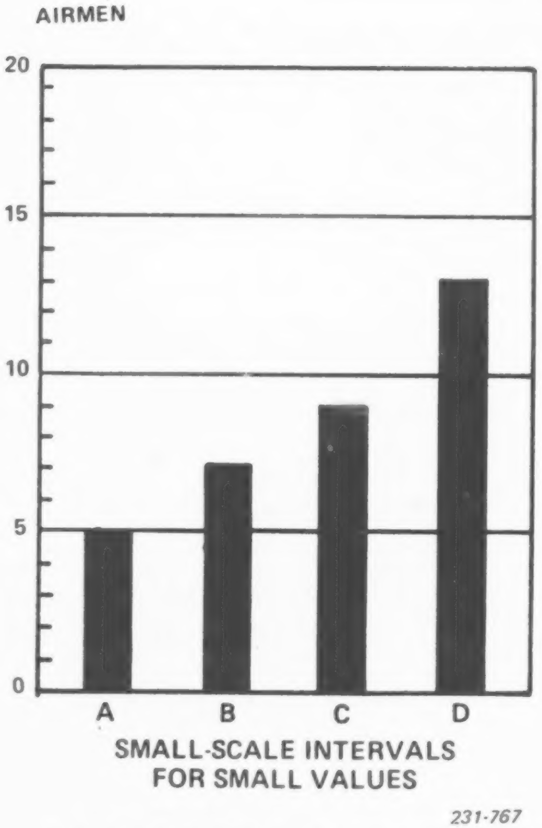


Figure 1-10. Small scale intervals for small values.

smallest value to plot is frequently the determining factor. If you have no values smaller than 100 units, there is not much point in selecting a scale interval of 5 units. On the other hand, if a number of values are below 25 units, you will have difficulty in plotting them if you use a scale interval of 50 units.

Another controlling factor in the selection of an interval is the variation of the values you are charting. Suppose, for instance, that the values you plan to chart are A = 5, B = 7, C = 9, and D = 13. The differences are slight. If you use a large interval, the variations among the columns will be lost, and accurate plotting will be impossible. This situation requires a scale interval of one unit, and also requires that a considerable amount of space be allowed for each unit. Figure 1-10 illustrates the correct use of a small interval when the variations in the data are small.

On the other hand, if your values are A = 175, B = 225, C = 300, and D = 350, you should use a fairly large interval and a small amount of space for each unit. Figure 1-11 illustrates the correct use of a large interval when the variations are large.

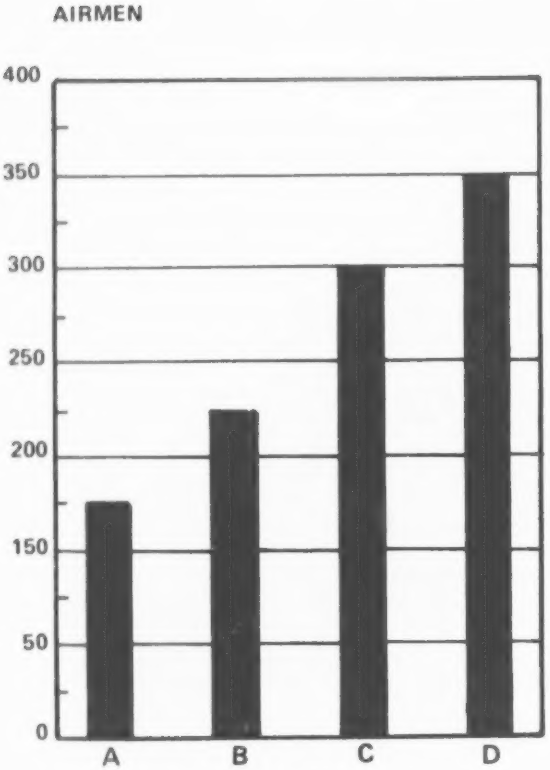
Although the charts you prepare will not normally be used to measure values accurately (no one will measure the height of a bar with a pair of calipers), they should be reasonably accurate in order for the comparisons shown to be realistic. This means that you mlust use some convenient measure of distance in the initial layout of the chart. If you plan to use a scale with ¾ inch (19.05mm) equal to one dollar, you are asking for trouble if you have such amounts as $167.75 to chart. It is much better to get yourself an engineer's scale showing tenths of an inch so that you can lay out your scale in multiples of ten, which are easier to compute. Another satisfactory alternate is to use centimeters, also based on multiples of ten.

Exercises (401):

1. Which type of table is best for presenting data covering a broad range on a specific subject?

2. Which type of table is best suited for highlighting specific information about a specific subject?

3. Give the six major elements of the body of a table.



LARGE-SCALE INTERVALS
FOR LARGE VALUES

231-768

Figure 1-11.

4. When data is portrayed on charts, how must it be presented?

5. What is the first thing to consider when you are selecting a scale?

6. Horizontal lines on the scale of chart serve what two purposes?

7. Why should scales always start at zero?

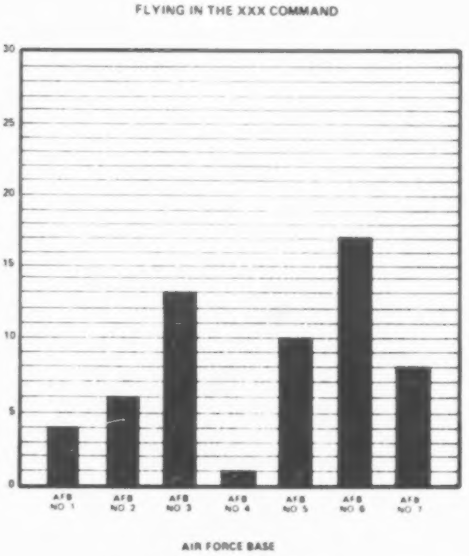
1-3. Display Charts and Graphs

To display information in a simple, easy-to-read manner, various types of charts can be constructed. You may be given the basic data in tabular form with the chart selection left entirely up to you. If this is the case, make every effort to choose a type of chart that will show clearly and simply the desired information.

Remember that a particular type of chart often does one particular job better than another type of chart. For example, *line charts* are used generally to compare numerical data for one or several items over a period of time. *Bar charts* show numerical data for different items at the same time. *Pie charts* show the divisions of a whole quantity into several parts. *Flow* and *organizational charts* show the classification of different objects or the cause-and-effect between two incidents. In this section, we will discuss some of the construction techniques and the advantages and disadvantages of each of the five types of charts mentioned.

402. Differentiate between the uses of bar, pie, line, flow, and organizational charts.

Bar Charts. The bar chart is probably the best known and the best adapted to show comparisons by size. As its name implies, the data is represented by bars or columns. The arrangement of the bars may vary according to the impression the analyst wishes to make. The conventional arrangement is to have the bars extend upward or grow from the base line at the bottom of the chart. This arrangement is called a *vertical bar chart*.



A POORLY CONSTRUCTED BAR CHART

231-769

Figure 1-12. Poorly constructed bar chart.

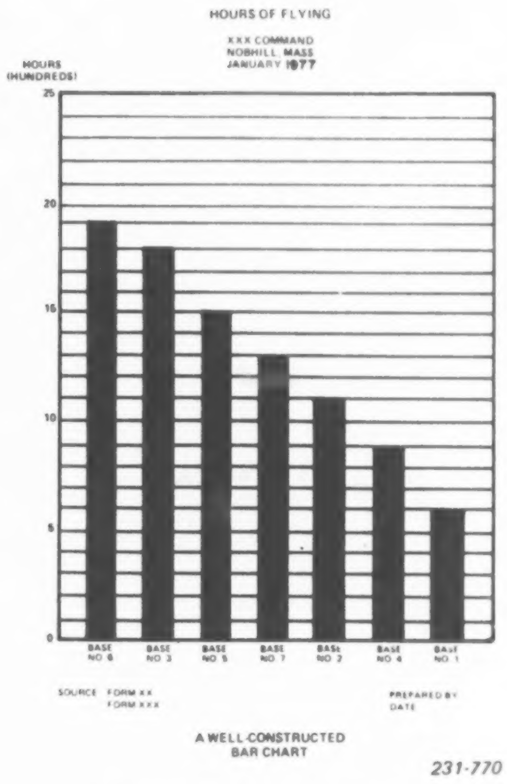


Figure 1-13. Well-constructed bar chart.

Frequently, in charts that show distances, horizontal bars are used. The bars extend horizontally across the chart from a base line either on the left or on the right side. The scale of values is arranged along the lower border or along the upper border. The upper location is preferable. It is generally undesirable to drop the bars from the top of the chart.

Sometimes you can use a split bar when you want to compare two portions of the same item in a chart comparing several items. On other occasions, you can subdivide each bar into segments, representing a fractional value of the entire bar. Set off such segments with colors, heavy or light lines, or cross-hatching. Actually, the arrangement and the treatment of the columns in a bar chart are almost without limit. But remember that, quite often, the more you put on a chart, the less effective it is.

The appearance of a chart is very important. An interestingly prepared chart attracts and holds attention, but a poorly prepared one generates indifference. By following certain basic principles and rules, you can always prepare an interesting chart.

Figure 1-12 illustrates a poorly constructed bar chart. Some of the obvious errors are errors of omission. The title is inadequate and can be interpreted in several ways. The bars are arranged without regard to size, making any direct comparison difficult if not impossible. The horizontal lines are not properly identified, and the authenticity of the data is open to question because the source is not indicated. It is impossible to tell who prepared the chart, when it was prepared, or what period of time the data represents. The tallest bar does not approach the top of the chart, producing poor artistic balance and making it almost impossible for a viewer to see the true comparative values.

Figure 1-13 illustrates a well-constructed bar chart of the same data shown in figure 1-12. The title tells what, where, and when. The scale is properly identified, and the lettering is clear and in a horizontal plane. A person does not have to turn the page sideways to read the titles of the bar items. The bars have been arranged in a descending order of magnitude, making it easy for a viewer to make a rapid, direct visual comparison between the several bases. All the descriptive matter on this chart, except the scale headings and source data, has been centered. This makes the chart neat and attractive. Every fifth scale line is darker so that you can better read the bar values.

The spacing between the bars in figure 1-13 is equal to the width of a bar. Generally, the space between bars should not be less than half a bar in width. It is difficult to read a chart that has a tall, narrow bar beside a short, broad bar. The arrangement of the bars requires your careful consideration. In this respect, the same rules apply to charts as to tables. You may arrange the data in ascending or descending order of magnitude. You may arrange it graphically, alphabetically, or chronologically. You may arrange it according to the emphasis desired or by some customary classification. In a bar chart, however, the arrangement is more critical. Comparison and contrast are more important in most cases than are other considerations, with balance and appearance a close second. Some arrangement by magnitude usually is preferable.

Frequently, for special purposes, it is desirable to show an average performance on a bar chart in addition to other statistical data which might otherwise have to be presented in a separate table. Figure 1-14 illustrates a descriptive bar chart with a stub containing detailed information, a bar chart for comparisons, and a dotted

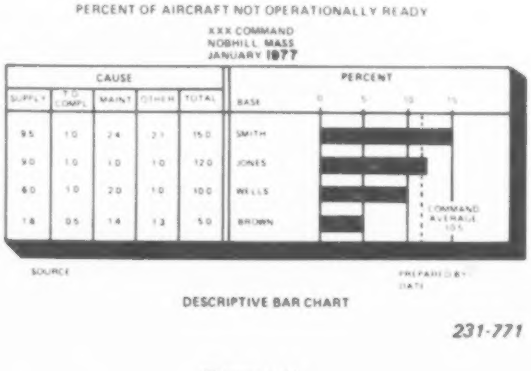
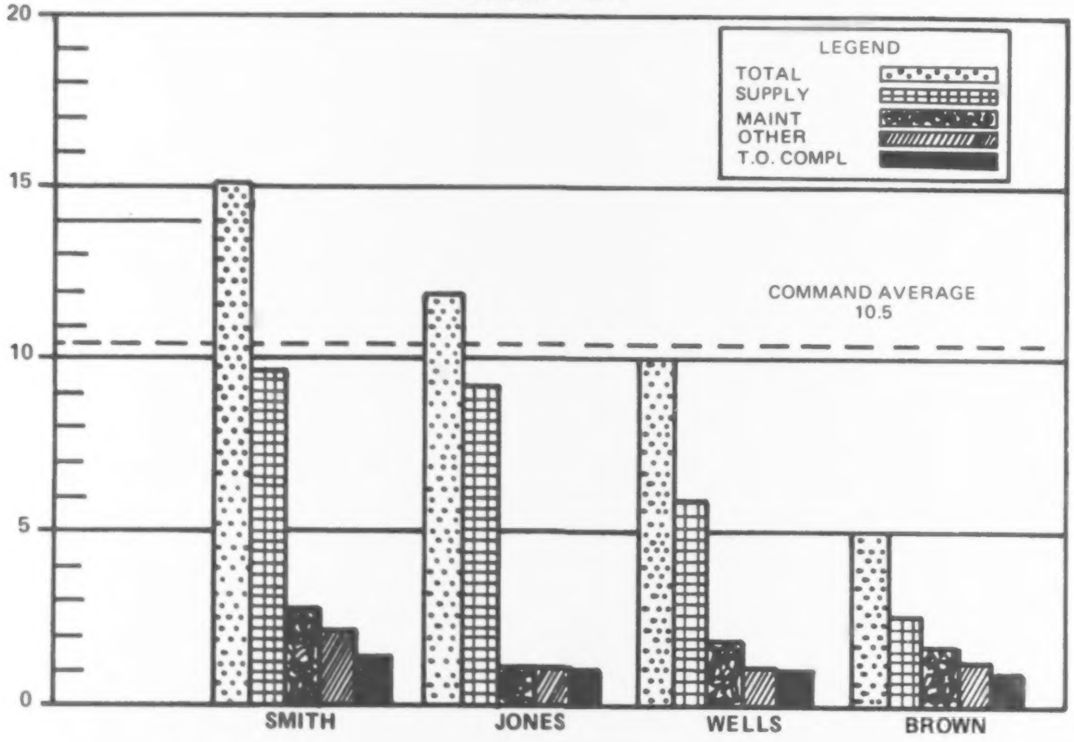


Figure 1-14.

PERCENT OF AIRCRAFT NOT OPERATIONALLY READY

XXX COMMAND
NOBHILL, MASS
JANUARY 1977



TOTAL	15.0	12.0	10.0	5.0
SUPPLY	9.5	9.0	6.0	1.8
MAINT	2.4	1.0	2.0	1.4
OTHER	2.1	1.0	1.0	1.3
T.O. COMPL	1.0	1.0	1.0	0.5

SOURCE:

PREPARED BY:
DATE:

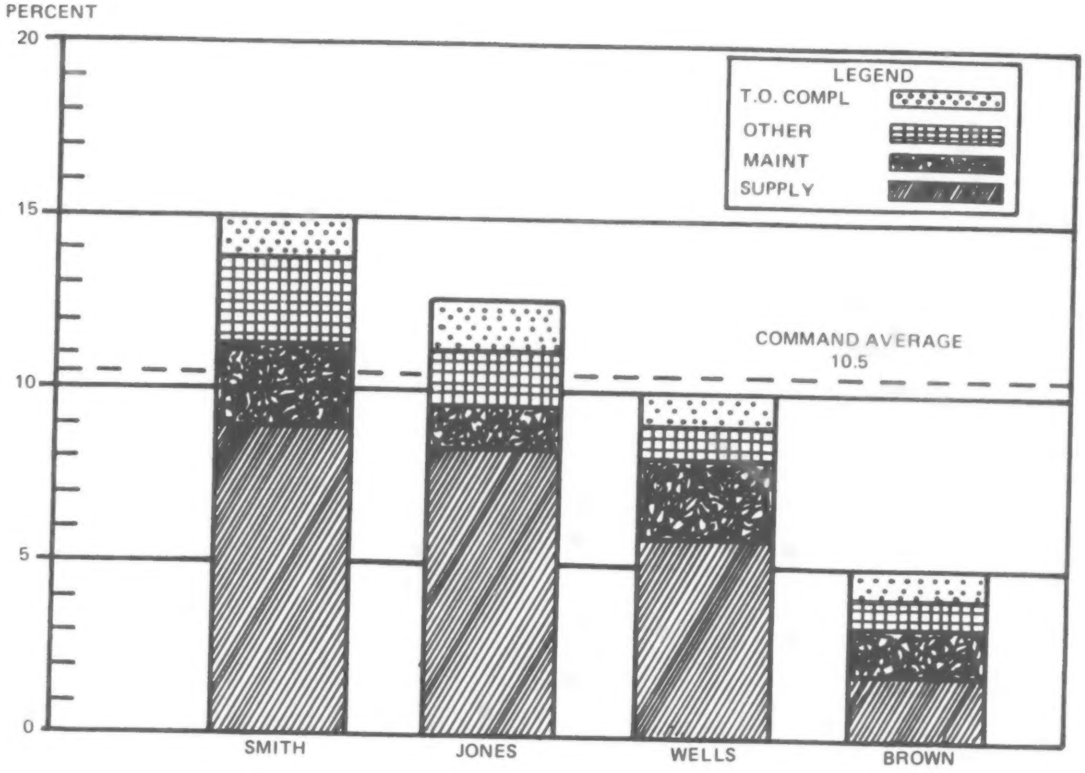
SPLIT BAR CHART

231-772

Figure 1-15.

PERCENT OF AIRCRAFT NOT OPERATIONALLY READY

XXX COMMAND
NOBHILL, MASS
JANUARY, 1977



T.O. COMPL	1.0	1.0	1.0	0.5
OTHER	2.1	1.0	1.0	1.3
MAINT	2.4	1.0	2.0	1.4
SUPPLY	9.5	9.0	6.0	1.8
TOTAL	15.0	12.0	10.0	5.0

SOURCE:

231-773

PREPARED BY:
DATE:

Figure 1-16. Segments of a bar chart.

line indicating the command average. This chart approaches the point where additional items will render it ineffective because of its complication. But as it stands, it presents in an attractive way a lot of information in a small space, on one piece of paper.

The same information can also be presented in two other types of bar charts. Figure 1-15 illustrates the same data on a chart using a split bar, and figure 1-16 displays this data by subdividing the bar into segments. Figure 1-15 is not as effective as are the other two charts because there are too many bars. They are easy to compare within each base but not easy to compare when you include all four bases.

Figure 1-16 is effective if you want to compare the totals of each base with each other base. It is not easy to compare the size of the maintenance segment of any one base with the maintenance segments of the other bases. There is an advantage, however. The proportion of each segment as related to the other segments within any one bar is readily apparent. The ratio of any segment to the whole bar containing it is also obvious.

The command average shown in figure 1-14 is not very effective because there is some doubt as to what the average represents. It is more effective in figure 1-15 but is the most effective in figure 1-16. In the design of a chart like figures 1-15 and 1-16, you may pay some attention to the organization of the columns and to the listing of statistical data under each column. The bases, or items, are listed in an overall descending order of magnitude in both instances. This order could be also in an ascending sequence.

In figure 1-15, the components of the columns are given in a descending sequence of the elements comprising the range of data. The bars for each base are arranged in exactly the same order. This is essential for uniformity within the chart and for easy location of any specific bar. However, it is not always possible to have an overall descending sequence of bars within every column. Sometimes the data just doesn't show up that way. For example, the "order" bar for Jones Air Force Base could have had a value of 2.0 and the "maintenance" bar only 1.0. If you have such a problem, it is **best to arrange the components so that most of the columns are similar in general outline.**

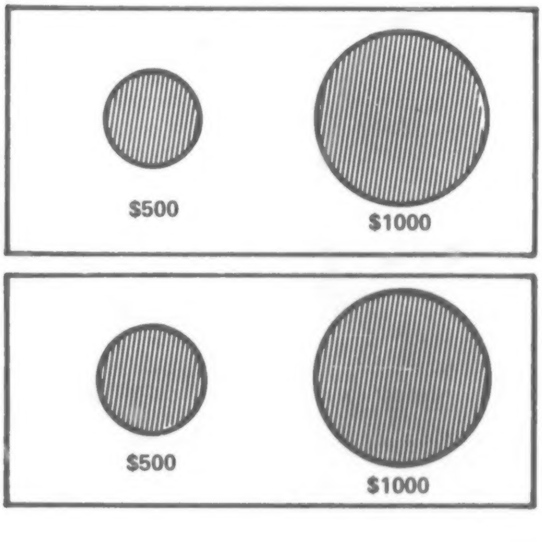


Figure 1-17. Pie chart (comparing sizes).

Do not rearrange the sequence of isolated columns to get a uniform outline because such rearrangement will upset the general pattern of the chart and destroy its uniformity. The arrangement of the statistical data under each base's column must follow the same sequence as the bars that represent the data. The same rule applies to the order in which the items of the legend are presented. There must be a direct relationship between the sequence of the bars, the statistical data, and the legend.

In figure 1-16, the sequence of the components of each bar differs from the sequence in figure 1-15. In this type of chart, the largest item should be at the bottom of the bar, the next largest on top of it, and so on with the smallest value at the top of the bar. Once again, it may not always be possible to have the same overall outline because the magnitude of each component will not always bear the same relationship to the total in each case.

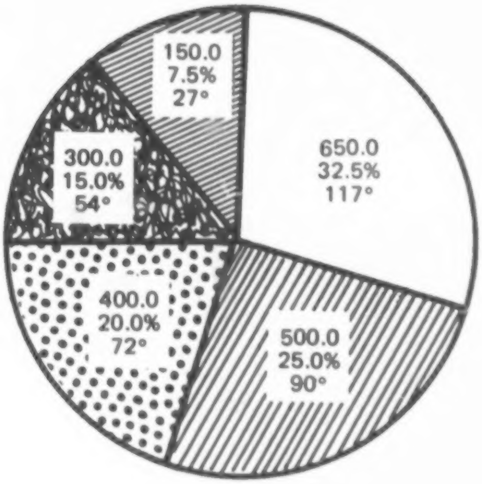
It is best to arrange the segments of the bars so that, in most cases, the rule will apply. Once you have established a sequence, do not change it. The arrangement within the legend should follow the same pattern.

For artistic balance, the larger areas at the bottom of the columns in a chart like figure 1-16 should be the darkest. The tones or colors should get lighter as they approach the top of the bar. In a chart like figure 1-15, the tallest bars should be the lightest in color or tone and the bars should get darker as they get shorter. If you cannot place the legend in the lower right of the chart, locate it over the shorter bars. The tallest bars will balance it out and the chart will have a more pleasing appearance.

Pie Charts. The pie chart is an excellent method of presentation within its limitations. It is a popular method, and in its field it is fully as effective as a bar chart. In comparing the parts of the whole, the pie chart is effective and is equally effective in comparing the parts of a whole with each other.

Be constantly on guard against making charts that are difficult to interpret at a glance. Two- and three-dimensional comparisons are difficult for the human eye to comprehend. For this reason, a comparison of size by means of circles (pie charts) is undesirable. Comparisons of size are done best by bar charts.

Figure 1-17 illustrates the difficulty of comparing size by pie charts. This figure is comparing $500 and $1000. In the upper half, the diameter of the $1000 circle is twice the diameter of the $500 circle, but to the eye, the $1000 circle appears to be much more than twice the size of the $500 circle. The eye is right; the area of the $1000 circle is four times the area of the $500 circle. In the lower half of figure 1-17, the area of the $1000 circle is



231-775

Figure 1-18. Percentage breakdown—pie chart.

twice that of the $500 circle. But in this case, the eye is deceived because the $500 circle does not appear to be half the size of the $1000 one.

Pie charts are most effective when they stand alone and represent 100 percent of the item under consideration. If you must use more than one pie chart on the same presentation, make them the same size each representing 100 percent of the subject.

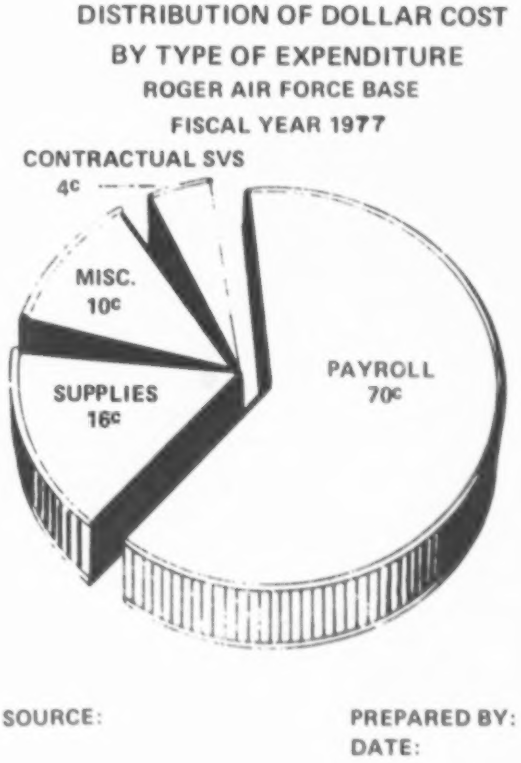
The manner of presenting a percentage breakdown is illustrated in figure 1-18. In this figure, there are five components comprising the 2000 units in the total. The circle itself represents 100 percent of the amount being illustrated which is 2000 units. The five components represent 150, 300, 400, 500, and 650 units, respectively.

The first step is to determine what percent of the whole each component represents. By simple division (the part divided by the whole), you find that:

150 = 7.5%
300 = 15.0%
400 = 20.0%
500 = 25.0%
650 = 32.5%
2000 = 100.0%

The next step is to find how many degrees of the circle you will need to represent each percentage. There are 360° in a circle, so 3.6° represents 1 percent. Multiply each percentage by 3.6° to solve this problem:

7.5 × 3.6 = 27°
15.0 × 3.6 = 54°
20.0 × 3.6 = 72°
25.0 × 3.6 = 90°
32.5 × 3.6 = 117°
100.0 percent = 360°



231-776

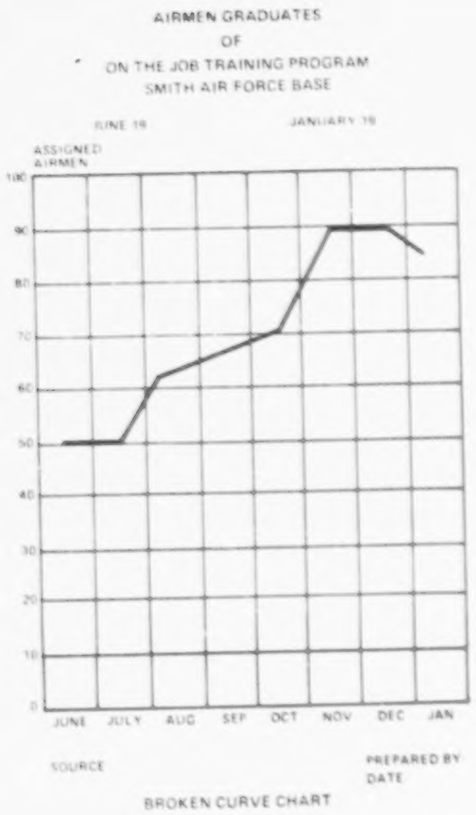
Figure 1-19. Color segment distribution pie chart.

If you use a compass and a protractor, it is a simple matter to lay out the segments of the circle to represent each of the component parts. Draw a radius from the center of the circle to the point on the circumference where 12 o'clock would be if the circle were the face of a clock. Lay out the largest segment to the right of the radius. Arrange the remaining segments in a clockwise sequence will appear to the right of 12 o'clock, and the smallest segment will appear to the left of 12 o'clock.

You can color each segment and use a legend to identify each element. It is customary, however, to label each segment and give its value on the chart itself. This method is illustrated in figures 1-18 and 1-19.

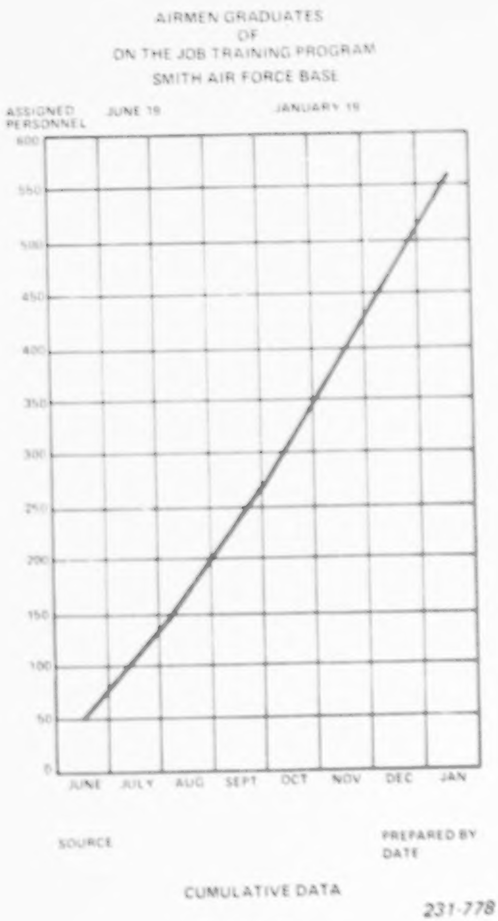
A pie chart is effective in presenting a distribution of costs. In figure 1-19, an Air Force base reported a distribution of costs of services in terms of 1 dollar. The individual items of 70 cents, 16 cents, 10 cents, and 4 cents total 1 dollar. The illustration shows that the base payroll represents 70 percent of the total operating costs. Supplies represent 16 percent of the total operating cost, miscellaneous costs are 10 percent, and contractual services cost 4 percent. If the total dollar costs are $500,000, it is fairly easy to compute the total dollar cost of each segment.

Line Charts. The line chart is a simple, effective means to present events that have occurred over a period of time (time series). A time series can be either cumulative or noncumulative.



231-777

Figure 1-20.



231-778

Figure 1-21.

For example, suppose you plan to use a line chart to show the number of flying hours each month. You can construct a chart that shows, for several months, the total number of hours flown each month (noncumulative). A line chart can also show more than one variable and can show an average or desired rate line.

A line chart sometimes is called an *historical curve*, because it describes data over a period of time. A bar chart has a definite break between each bar, but a line chart runs continuously from point to point with no breaks at all.

Since the eye can follow a line naturally and easily from one point to the next, the line creates an impression of data moving through time and the magnitude of the data. Some of the line charts are *broken curves, smooth curves,* and *step curves.*

Figure 1-20 shows a broken curve chart. The points represent quantities for each month and are connected by straight lines. This data is noncumulative, or point data, which means that the values plotted for each month represent only the total for that individual month or point in time.

When you read a chart of this type, keep in mind that the lines between the plotted points are only connecting the points. They establish the direction in which the data is moving and have no other value. For instance, in figure 1-20 there are 60 cases in August and 50 in July. Halfway between these two months the curve crosses a point representing the quantity of 55 on the vertical scale, but this does not mean the 55 airmen were graduated from on-the-job training at this time. The curve, or line, only carries the eye from point to point, creating the impression of a movement through time.

In this type of line chart, as in all other charts, it is essential for the plotted data to be as of the same day of the month for each month. If different dates are used for the various months, the fluctuations revealed by the line are not true.

Figures 1-21 shows cumulative data in the form of a smooth curve. The plotted points in this case are running totals. The point total for July (50) has been added to the point total for June (50), giving a cumulative total of 100. The 100 is plotted on the chart for July. In August there were 60 graduates, or a cumulative total of 160. The 160 is plotted on the chart for August.

From a cumulative chart, you can read intermediate values from the smooth curved line—that is, if graduations take place on an almost daily basis. If airmen are graduating from the on-the-job training program every

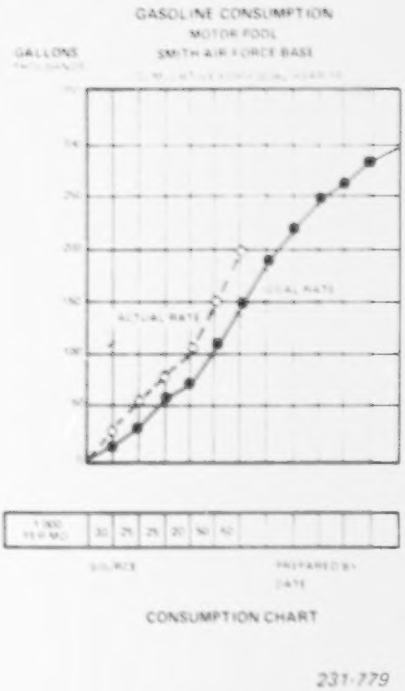


Figure 1-22.

day, you can determine that on 1 July there were 75 cumulative graduates. The curved line in figure 1-21 crosses the point representing 1 July at the scale value of 75.

Cumulative line charts are very effective in illustrating the growth or decline of any activity. They also are valuable for control purposes when they are maintained on an as-it-happens basis in conjunction with a preplotted average or ideal rate line.

For example, figure 1-22 is a gasoline consumption chart prepared for the motor pool. The funds allotted for the fiscal year will buy 300,000 gallons of gasoline. Because of snow removal and other heavy winter demands, the ideal rate of gasoline consumption is high for the winter months and low for the summer months. The ideal rate line is the goal to be achieved if the motor pool is to stay within the 300,000 gallons available. At the end of each month, the total gallons used that month are added to the previous cumulative total and are plotted on the chart.

A glance at the chart will show you that the motor pool is using too much gasoline. Unless economy measures are enforced, the gasoline available for the rest of the fiscal year will be less than the anticipated need. A chart of this type is of more value than a bare statement of facts, because on the chart the dangerous trend is readily apparent.

A step curve, shown in figure 1-23, is limited in use. If the changes are known to be abrupt, a step curve is an effective means of presentation. The disadvantage of a step curve is that the trend, or feeling of movement of the data through time, is lacking. Even more objectionable is the fact that, when two or more series are plotted on the same chart and the lines cross or fall on the same vertical or horizontal grid line, the reader is confused, and the chart loses effectiveness.

Line charts showing more than one variable are effective in showing data on similar subjects. The entire airman training situation is illustrated in one chart, as shown in figure 1-24. This chart shows end-of-month data on how many airmen are in on-the-job training and formal schools and the total of both. One chart takes the place of three. The statistical data is shown in the stub at the bottom of the chart. This type of chart is most effective when the number of variables is limited to two or three and when the differences in their values are sufficient to separate the trend lines enough for easy reading.

Before leaving the subject of line charts, we must give you some information about the selection of scales. The general rules which were discussed in the early part of this section apply also to line charts.

The spacing to be used for the items across the bottom of the chart has not been discussed. In column or bar charts, this spacing is not so important, but in line charts it is. Generally, if the chart is divided into squares, the proportions will be satisfactory because the

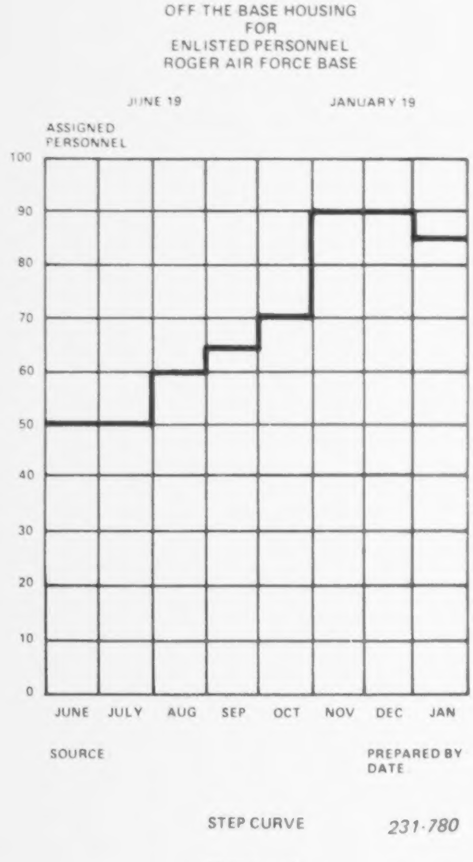
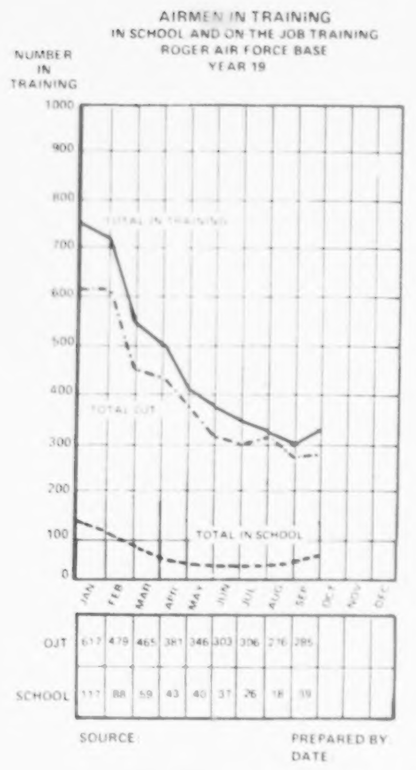


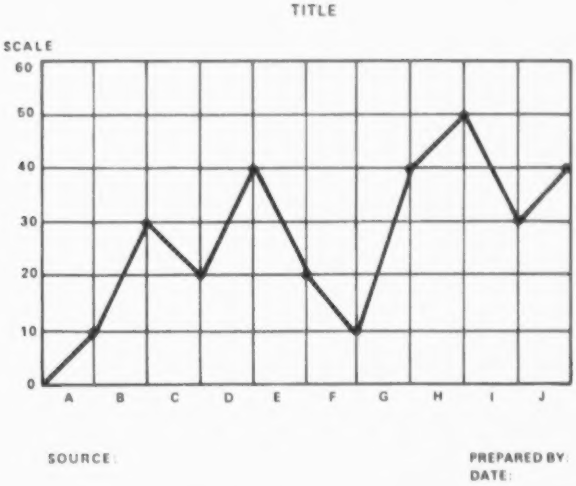
Figure 1-23.



LINE CHART SHOWING THREE VARIABLES

231-781

Figure 1-24.



231-782

Figure 1-25. Ratios (1-1).

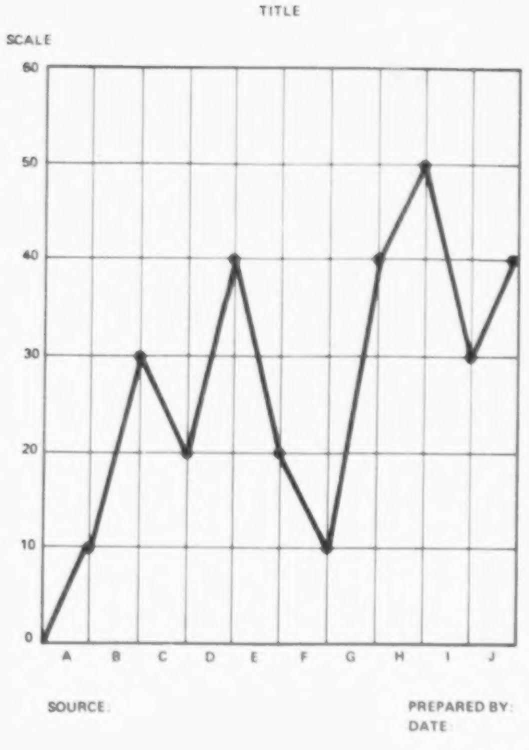


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Figure 1-26. Ratios (2-1).

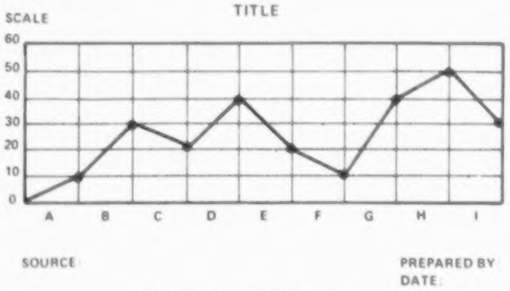


Figure 1-27. Ratios (1-2).

distance from the zero on the scale to the horizontal line for the first major value should be the same as the distance from the zero to the first vertical line representing a month or other unit being charted.

Figures 1-25, 1-26, and 1-27 illustrate the impressions given when the distances between the items vary. In these three figures the data is the same, and the scales are the same. Only the space between the items has changed. In figure 1-25, the ratio of scale space to item space is 1 to 1, resulting in squares. In figure 1-26 the ratio is 2 to 1, and in figure 1-27 the ratio is 1 to 2. Figure 1-26 gives the viewer the impression that the fluctuations are sharp and the variability is great. Figure

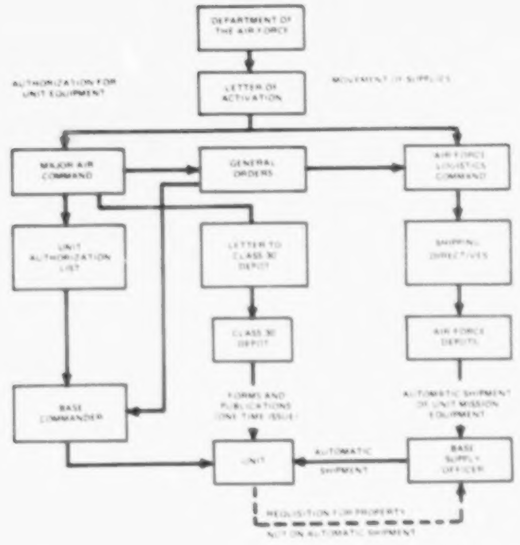


Figure 1-28. Flow chart.

1-27 gives the viewer the impression that the fluctuations are gentle and that the variability is small.

It is possible, by a clever manipulation of the ratio of the scale distance to the item distance, to make data seem to be almost smooth though it actually fluctuates widely. Conversely, data that is smooth can be made to appear to fluctuate sharply. Be constantly on guard against distorting facts by a poor choice of distances on line charts.

Flow Charts. The flow chart is used primarily for showing the progressive steps of an operation. It is used in manufacturing, for example, to point out operational steps in a production line. It is a clear way of explaining the procedural steps of a functional unit to the uninitiated. The flow chart is used to great advantage by the military.

Figure 1-28 illustrates the many steps in supplying an Air Force organization. By following this chart, you can understand the procedure, from the original letter activating the organization to the actual receipt of the necessary supplies. The chart designer knew that balance was necessary if the result was to be clear and pleasing to the reader. Numerous rough drafts were made and several types of lettering were tried before the chart was completed.

To get a better understanding of a flow chart, look again at figure 1-28 and follow the steps. Take, for example, the movement of supplies portion. At the top of the chart the Department of the Air Force initiates the original letter of activation which is submitted to the Air Force Logistics Command. From this point, shipping directives go to the Air Force depots concerned. It is then the responsibility of the Air Force depots to forward the required unit mission equipment to the base supply officer who, in turn, must see that the equipment reaches the proper organization. Because supplying a newly activated organization is such a large operation, you can expect that many items will be overlooked. If this occurs, the chart shows what action to take. The unit will submit a requisition to the base supply officer for the property omitted in the initial automatic distribution.

Follow the chart down the opposite side which concerns authorization for the unit equipment and note the ease with which you can follow every move. In comparison, try to explain the same operation verbally. Try to use words that describe every step adequately and, at the same time, are as easily understood as the chart in figure 1-28.

Organizational Charts. In every industrial, commercial, educational, and military organization, it is necessary to show each individual his or her authorized duties and responsibilities as they relate to others. The organizational chart is the most common one for this purpose. This chart consists of blocks representing the various offices arranged so that their placement shows the relative position of each office.

Figure 1-29 is an example of an organizational chart for a maintenance unit. Note that the largest block shows the name of the unit. In the line of command, three shops are shown. Under each of these are several blocks in which sections of workers can be shown. The block above shows the office to which this unit is responsible. Notice that the two staff functions—administration and inspection—are not in the line of command.

It is not easy to establish standard ways of constructing organizational charts. Many offices and commands insist on very exacting formats. But the following basic rules are followed in most units:

a. On any individual chart, show one level above and two levels below the primary organization or person being charted.

b. Use a rectangle to represent a unit or a person on the chart. Use straight vertical and horizontal lines to show the command or authority line.

c. Make the rectangle representing the person or unit around which the chart centers the largest one on the chart. The rectangle above and the ones below the key figure should be smaller. The rectangles on each lower level become one size smaller.

d. Show the rectangles on the same level of equal size and on the same horizontal line.

e. Normally, the authority or command lines enter each rectangle at the center of the top and leave at the center of the bottom or from the left of the rectangle. Command lines do not run through a rectangle.

f. Normally, staff units or personnel are placed under the person or unit that they serve and above the line units. If there is only one staff unit, it is usually placed on the right.

In addition to an organizational chart showing only the offices in a chain of command, there are two other types of organizational charts. In a functional organizational chart, each major area of work is shown under the office name. Since these statements of function require additional space, the blocks and the

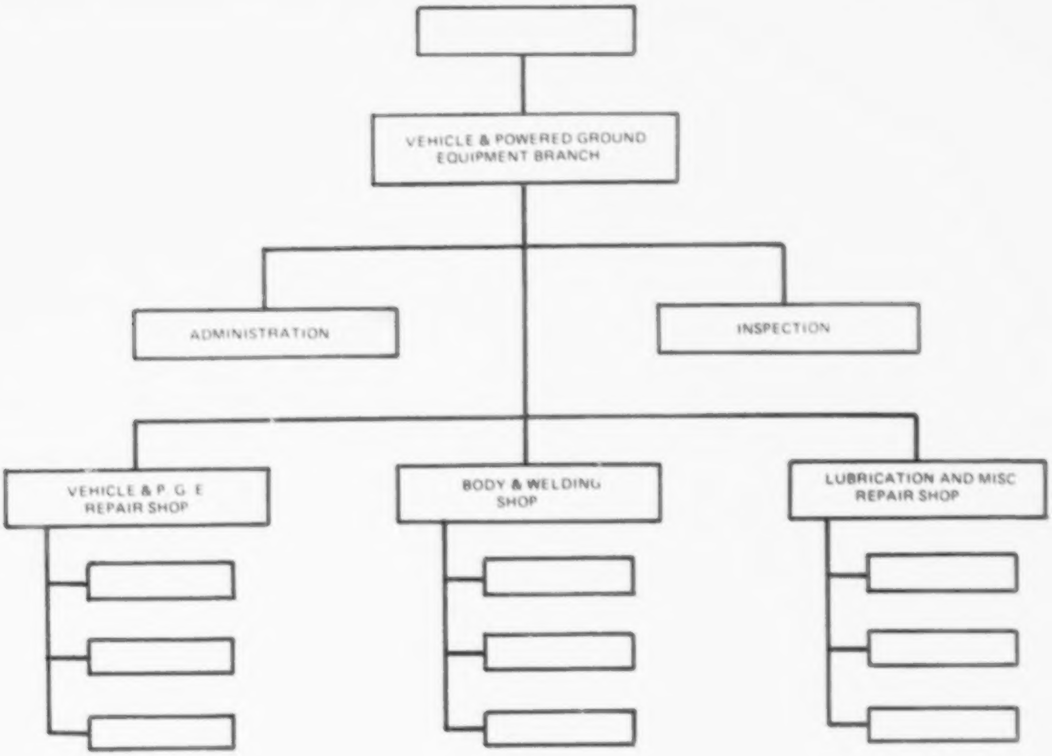

VEHICLE & POWERED GROUND EQUIPMENT BRANCH
ADMINISTRATION
INSPECTION
VEHICLE & P. G. E REPAIR SHOP
BODY & WELDING SHOP
LUBRICATION AND MISC REPAIR SHOP

Figure 1-29. Organizational chart.

entire chart may have to be larger than that shown in figure 1-29.

Sometimes an office or unit needs a chart showing the place of each worker and supervisor. Such a chart is usually called a personnel chart or placement chart. Though these charts may require many more blocks than a plain organizational chart, the same basic rules should be followed.

Exercises (402):

1. What chart is best suited to show size comparisons?

2. What is the most effective chart for comparing parts of a whole to the total?

3. What chart is sometimes called a historical curve?

4. How is the flow chart used primarily?

5. What type of chart can show authority and responsibility as it relates to one individual?

6. What impression does the line create on a line chart?

7. Why is the appearance of a chart important?

8. What is one of the first steps in constructing a pie chart?

9. How do you determine the percentage of a section of a pie chart?

10. How do you determine the amount of degrees that are necessary to represent each percentage of the pie chart?

CHAPTER 2

Projectual

~~Projectional~~ Design

WHEN THE ORIGINAL illustration is to aid communication, the illustration may be produced in any medium and with any technique that is effective for the presentation. For example, if a chart is to be used by a commander to present information, it can be produced in the most suitable medium and by the techniques that effect the desired results. Since there are few restrictions on the media and techniques that may be used, there is a large selection from which to choose the appropriate media and techniques for the occasion.

When more than one copy of the illustration is required, the method of reproducing the needed copies must also be considered in selecting the media and technique used to produce the original illustration. The method and process of reproduction may limit the number of media and techniques that can be used to produce the original illustration. Therefore, you must know something about the various methods and processes of reproduction to be able to select the most appropriate medium and technique for any illustration that must be reproduced. The information on printing processes and on the most important methods of reproduction presented in this chapter should give you this basic knowledge.

2-1. Methods of Reproduction

Copies of illustrations or drawings are often needed for work copies, samples, information, and file copies. In many cases you will be the one who makes these reproductions, using available reproducing machines. The two most common reproduction methods are diazotype and dry electrostatic transfer.

403. Contrast the wet and dry process methods of diazo reproduction.

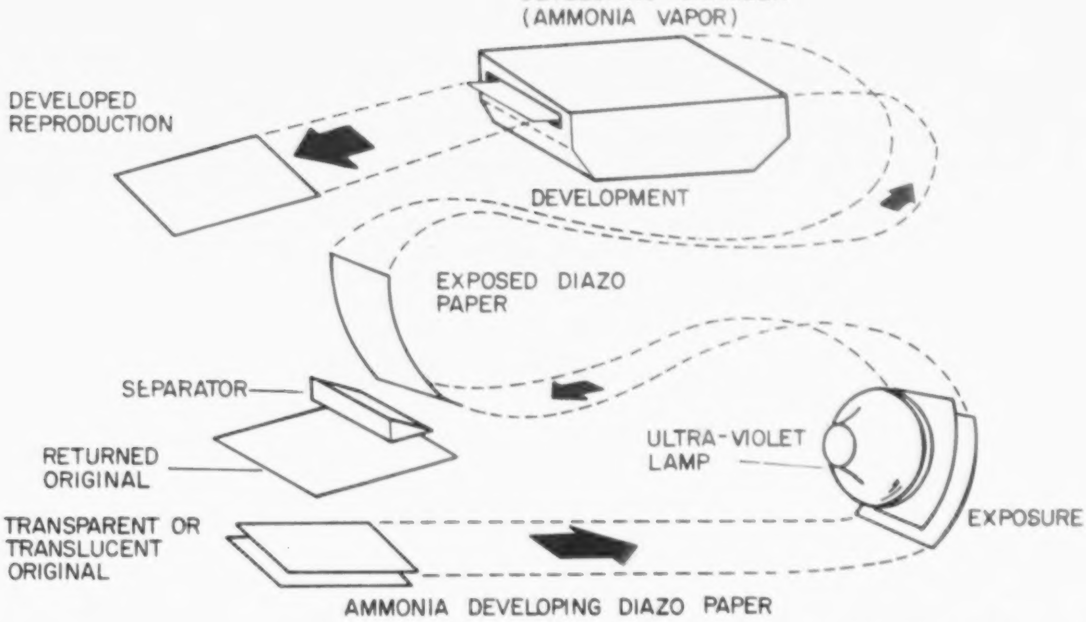
Diazotype. Diazotype reproduction is possibly the most versatile and effective nonphotographic reproduction process. The process is simply a contact exposure of a light-sensitive paper to ultraviolet light through a translucent original (master). Development is a one-step alkalizing process that takes place in a single automatic machine; it exposes the light-sensitive paper, ejects the original or master, and develops and dries the reproduction copy. The resulting print (reproduction copy) is positive; that is, light and dark areas correspond to the master. (In a negative print, light areas become dark and the dark areas become light.)

When you make a drawing that is to be reproduced by diazotype reproduction, the paper you use (the master) must be translucent or transparent. Generally, the drawing is not inked; however, inking may be done if a particular situation requires it.

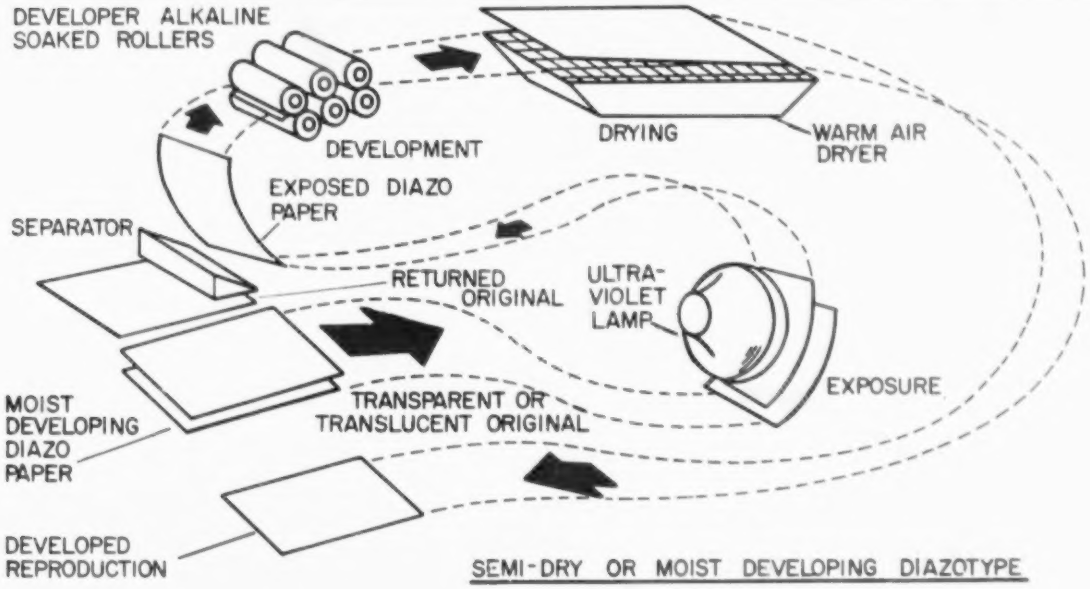
Basic techniques of producing diazotype images. There are two basic techniques of producing diazotype images, each requiring specialized processing equipment and noninterchangeable senstitized materials. The systems are called dry developing, or ammonia developing, process and semidry, or moist developing process. The ingredients or chemical makeup of both processes are basically the same. They consist of a diazonium salt and a coupler. The diazonium salt, commonly called diazo, and the coupler are coal tar or petroleum derivatives that combine to form a dye. The formula of the coupler determines the color of the dye image. The diazo is the light-sensitive component of the formula. The large variety of compounds that fall into the diazonium salt and coupler groups allows a wide span of exposure and reaction times and variety of dye images.

Developing processes. The process is simple for developing both dry and moist diazotype reproductions. The reproduction cycles for both processes are shown in figure 2-1. When ultraviolet light strikes the diazo through the translucent portion of the master, the normally yellowish diazonium salt undergoes a chemical change and becomes a new, colorless, inactive compound. In the ammonia (dry) developing process, both the diazo and the coupler are included in the sensitizing formula that is stabilized by a mild acid to prevent premature coupling. In the moist developing process the diazo is on the paper, and the coupler is in the developing solution.

After exposure through the translucent master to ultraviolet light, the master is ejected from the machine and the exposed paper conveyed to the developing portion. In the ammonia (dry) process the exposed material (diazo and coupler on the paper) is passed through an aqua ammonia vapor where the stabilizer is counteracted by the alkalinity of the ammonia. The diazo that has not been exposed then combines with the


DEVELOPING CHAMBER
(AMMONIA VAPOR)
DEVELOPED REPRODUCTION
DEVELOPMENT
EXPOSED DIAZO PAPER
SEPARATOR
RETURNED ORIGINAL
ULTRA-VIOLET LAMP
EXPOSURE
TRANSPARENT OR TRANSLUCENT ORIGINAL
AMMONIA DEVELOPING DIAZO PAPER

DRY OR AMMONIA DEVELOPING DIAZOTYPE


DEVELOPER ALKALINE SOAKED ROLLERS
DEVELOPMENT
DRYING
WARM AIR DRYER
EXPOSED DIAZO PAPER
SEPARATOR
RETURNED ORIGINAL
ULTRA-VIOLET LAMP
EXPOSURE
TRANSPARENT OR TRANSLUCENT ORIGINAL
MOIST DEVELOPING DIAZO PAPER
DEVELOPED REPRODUCTION

SEMI-DRY OR MOIST DEVELOPING DIAZOTYPE

Figure 2-1.

coupler to form a dye image. In the moist developing process, the exposed paper is moistened by the alkaline developer solution that contains the coupler. Where the diazo was unaffected by the light, a dye image is formed.

At this time, the dry (ammonia) process is used more extensively. The ammonia process has a larger variety of compounds and is somewhat more versatile than the moist process. However, the moist developing process has the advantage of not emitting ammonia odors. Both processes are capable of producing high-quality prints.

Second originals. Since the translucent paper on which the original (master) drawing is drawn wears out after a few reproduction copies are made, a "second original" is often made. This second copy is made on special foils or acetate (both translucent) coated with the same substance as that used on the light-sensitive reproduction copy paper. Because the material used for the second original is much more durable than the paper of the original, many more reproductions can be made by using the second original as the master.

Diazotype reproduction in general. Diazotype reproduction produces a positive print that is quite stable on hard-finish papers, plastic-coated papers, and acetate sheets. There is a tendency for the print on the cheaper, softer papers to oxidize slowly. Long storage or exposure to heat or sunlight can cause these cheaper papers to discolor, and to become brittle, and also cause the image to fade slightly.

The speed at which the ammonia process diazo runs is generally faster than the moist developing process. There is a wide variation in the running speeds depending upon the sensitizing compound on the paper. Diazotype reproduction paper is available in either sheets or rolls of various dimensions. Generally, the color of the image is blue, sepia, or red.

Exercises (403):

1. What is the difference in the developing process between the wet and the dry methods of diazo reproduction?

2. Why are second originals produced?

404. Cite the advantages of diazo transparencies and the method for determining letter height.

Diazo Transparencies. The diazo transparency is probably the most commonly used view graph slide for permanent briefing and training aids. To make your projectual transparency using this process, you do your basic artwork with black drawing ink on translucent paper. Layout your lettering, using the photo composing machine with adhesive-backed 35mm film, on an 8½ by 11-inch (215.9-mm x 279.4mm) clear acetate sheet. This will give you great flexibility for changing or rearranging the wording. The adhesive-backed photo composing film, used with the clear acetate sheet, lets you move words and sentences around with a minimum of difficulty and still have a good piece of basic artwork. You can also type, using tracing paper sheets and reversing the carbon paper behind the tracing paper, so that you have a typed image on both sides of your tracing paper.

A handy technique, which enables you to keep all your drawings and/or printed matter centered and within the aperture of the normal view graph slide mount, is to make a view graph slide layout board. Take a piece of graph paper, 10 by 12 inches (254.0mm x 304.8mm), and secure it to a piece of cardboard or scrap illustration board. Using a ruling or reservoir pen, lay out a 7½ by 9½-inch (190.5mm x 241.3mm) aperture area on your graph paper and mark off the horizontal and vertical centers of the aperture area. With the view graph slide mount aperture area and the center lines marked off on your graph paper, this layout board should eliminate problems of overrunning the aperture area or getting imagery off-centered. Just place your tracing paper or acetate sheet squarely over your layout board and secure it with tape. You can see the lines from the graph paper and your center lines through either the tracing paper or the acetate sheets and have a perfect reference for building your slide artwork.

Since the size of your basic artwork is quite large, 7½ by 9½ inches (190.5mm x 241.3mm), it is easier to work with than smaller slide drawings. You can get more detail on the drawing and you can work with a bolder stroke. Another advantage in making diazo transparencies is that you can literally cut out your mistakes. If you make a mistake on the tracing paper, you simply cut out the incorrect part and tape a new section (using translucent mending tape) in its place.

After your basic artwork is finished, your job is practically done. You merely have to place your master on top of a sheet of sensitized film and run it through the diazo developer machine at the proper speed. The diazo machine exposes the master and film to ultraviolet light and then bathes it in ammonia fumes. The developing process is all done automatically. Lacking a machine, you can achieve the same results with a sunlamp and an ammonia vapor bath, using a gallon jar with a sponge saturated with ammonia in the bottom and covering it with a grid to keep the film from touching the ammonia.

The same diazo process adapts to the production of color slides. By producing separate film sheets of the appropriate colors and assembling them in an overlay, you can create a full color transparency.

Always mount diazo transparencies in commercially prepared view graph slide mounts. These mounts are usually procured from the same sources as the diazo acetate film sheets. The mounted transparencies are easier to handle when you are projecting on the screen, using an overhead projector, and filing. Use masking

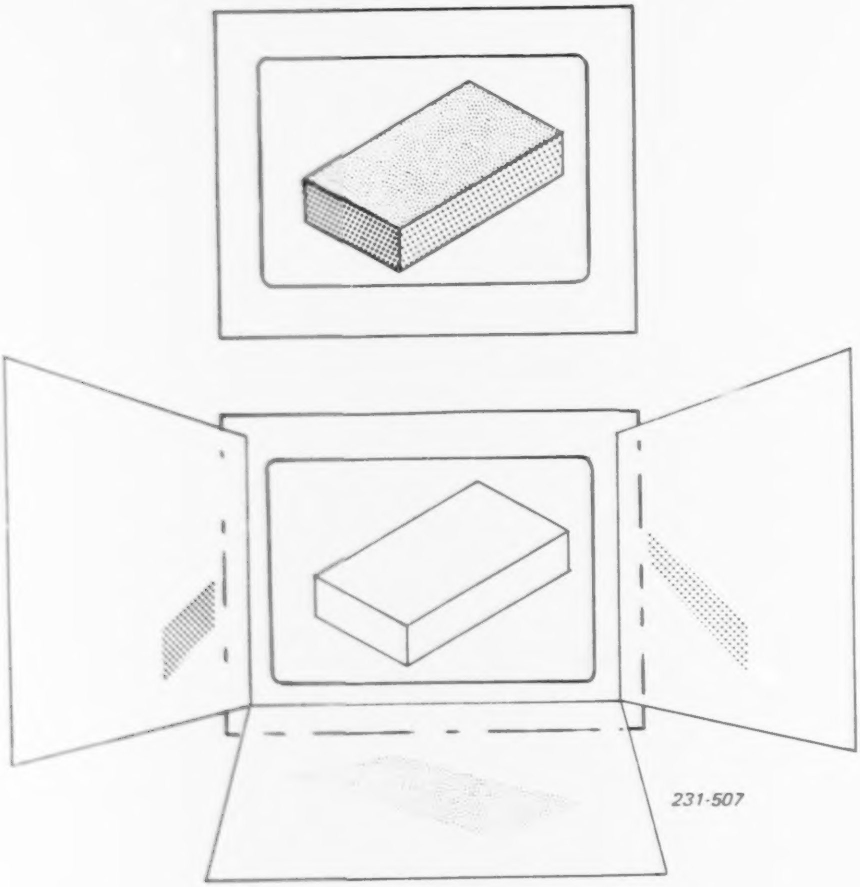


Figure 2-2. Static projectual.

tape to secure your transparency to the slide mount; never use staples. Staples can damage the projectural transparency during handling and filing. The commercial mount should fit in a standard filing cabinet, but if you must trim the mount, leave at least a 1-inch (25.4mm) margin all the way around the projectual to provide the desired rigidity. This type of projectual is shown in the upper portion of figure 2-2 commonly known as a view graph slide.

When a single graphic unit is too complicated to be represented by a single projectual, you can break it down into simpler components by the overlay technique. You process each overlay sheet separately, starting with the basic transparency. Then tape the mount of the first overlay to the basic mount so that it is hinged on one side and can be folded back away from the basic or will lie directly on top of the basic. Continue the process until all overlays are in place. If the sequence in which the total graphic unit is built up is always the same, hinge the overlays on the same side of the basic mount. If the sequence varies, then you must hinge them on a different side, top, or bottom of the basic projectual, as shown in the lower portion of figure 2-2. This type of projectual is sometimes called a *dynamic projectual.*

Registration is the most important factor when combining two or more transparencies. It is absolutely necessary to make sure that the overlays coincide with each other correctly. Registration is done as the artwork is completed. As each overlay is completed, registration marks are placed in the margin areas outside the aperture areas. Align the registration marks on each succeeding overlay. This will insure the proper alignment of transparencies as they are taped to the frame.

Determining Minimum Lettering Height for Overhead Projectuals. The minimum height for the lettering on overhead projectuals depends on the distance of projection and the distance between the screen and the farthest viewer. Calculating this minimum height is a complex mathematical operation. You have to consider such factors as 20/20 vision and how much the projected image will be enlarged. Therefore, the operating instructions of most projectors include such charts as the one shown in figure 2-3 which does the calculating for you. All you need to use with this chart is a straightedge. Let's see how the chart works.

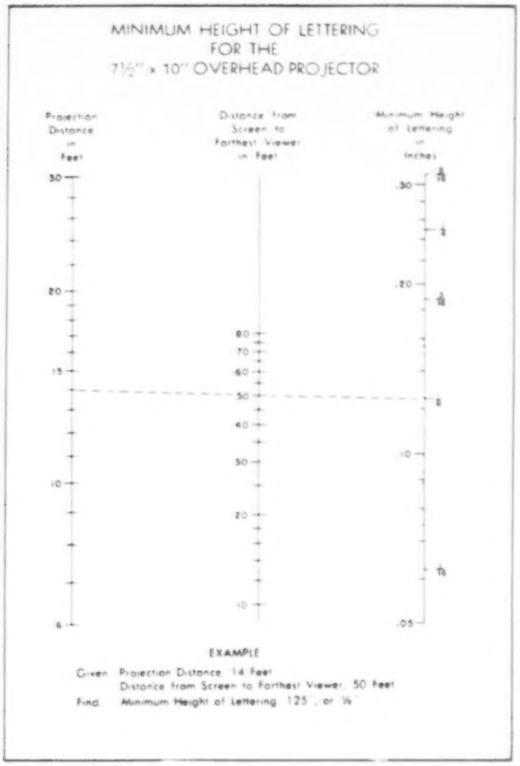


Figure 2-3. Height of lettering.

To design the lettering on a projectual, you must know the distance between the projector and the screen and the distance between the screen and the farthest viewer. Let us suppose that these distances are 14 feet (4.2672m) and 50 feet (15.24m) respectively. To find the correct height, align your straightedge on point 14 on the left scale and on point 50 on the center scale. The straightedge then intersects the scale on the right between the point .12 and .14, and, as you can see, it intersects the scale closer to point .12 than .14. Notice that the right scale is also marked off in fractions of an inch and that our point of intersection is marked 1/8. This 1/8 inch (3.175mm) is the minimum height for th lettering on the projectual. Now, you try one, using feet (9.144 m) for the projection distance and 60 fe (18.288 m) for the distance of the farthest viewer. If you get 1/16 inch (1.5875mm) for the minimum lettering height, you've got the idea. If you did not get that answer, try again.

Exercises (404):

1. Give two advantages of diazo transparencies.

2. What can you use for calculating the minimum height of the lettering to be used on an overhead projectual?

3. What is the most important factor when producing a multicell transparency?

405. Cite operating principles and advantages of the dry electrostatic process.

Dry Electrostatic Transfer. This method, commercially known as the Xerox process, is a fast, dry electrostatic process that uses ordinary paper or specially made film. It has advantages that make it flexible, versatile, and an economic means of production.

While the preparation of paper offset masters is the most popular use of the dry electrostatic transfer process, it is equally easy to prepare transparencies. This process can also produce single or multiple copies on ordinary paper.

Here is how the dry electrostatic transfer process works:

(1) The surface of the selenium-coated plate is electrostatically charged as it passes under wires.

(2) The original document is projected through a camera lens. The charge on the plate is drained away in areas that are exposed to light.

(3) Negatively charged powder is spread over the plate and it adheres to the positive image. The latent image becomes visible.

(4) A sheet of paper (paper offset master or transparency) is placed over the plate and given a positive charge.

(5) The positively charged paper attracts the powder from the plate, forming a direct positive image.

(6) The powder is then fused to the paper with heat to make the image permanent.

The Xerox process has its limitations. The equipment is delicate (the plates are quite easily damaged) and the copy loses clarity.

The Xerox process is of considerable value in intermediate publication work. It is especially useful for preparing masters for other duplicating processes. The process is fast, usually requiring less than 5 minutes for completion of the process. Although the reproduction is permanent and economical, the oeprating materials (plates, powder, and maintenance) are somewhat expensive.

Exercises (405):

1. What kind of paper is used in the dry electrostatic transfer process?

2. How is the image made permanent?

3. What is one of the major advantages of the dry electrostatic process?

405a (419—for CE feedback reference only). Cite the operating steps and advantages of using the Thermofax process.

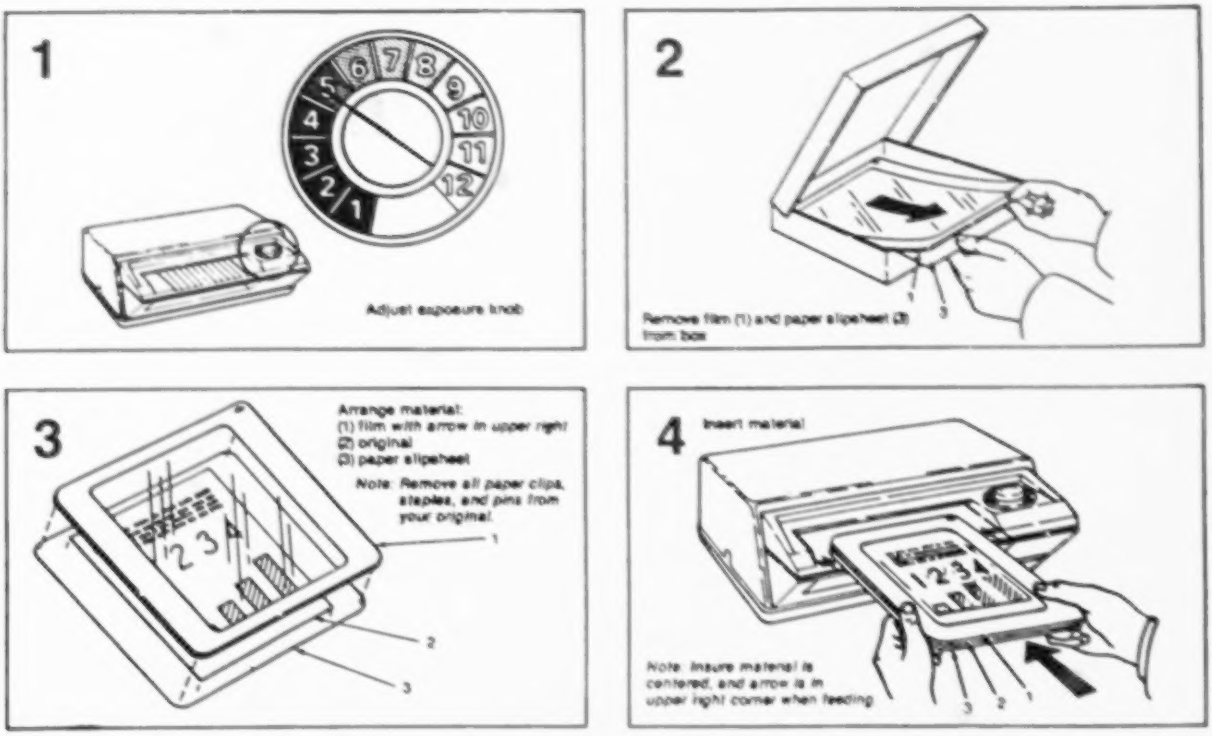
Thermofax Transparencies. We have discussed the diazo method for producing transparencies. An alternate method for producing overhead transparencies is with the use of the Thermofax infrared process.

Although the Thermofax process does not produce the same quality transparency as the diazo process, the Thermofax has many advantages. The Thermofax is very flexible. You can produce a transparency using practically any printed material. The Thermofax can also produce spirit masters, gummed labels, laminates, and paper copies.

This process is very helpful for low-priority, short-suspense briefings. It is easy to operate and very economical. The Thermofax is most effective in the self-help area of your shop.

Operation. There are four steps to producing a transparency using the Thermofax: (1) adjust the exposure, (2) place the film on the original (the notched corner should be in the upper right hand side); (3) center the material and insert it into the machine; and (4) mount the transparency (see figs. 2-3a, 2-3b, and 2-3c, which have been provided through the courtesy of the Audio/Visual Division of the 3M Company).

How to Image Preframed Film for Infrared Copiers



Adjust exposure knob

Remove film (1) and paper slipsheet (3) from box

Arrange material:
(1) film with arrow in upper right
(2) original
(3) paper slipsheet

Note: Remove all paper clips, staples, and pins from your original.

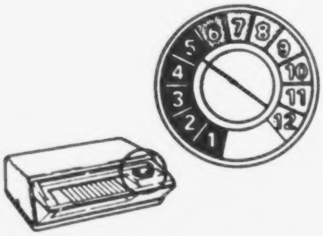
Insert material

Note: Insure material is centered, and arrow is in upper right corner when feeding

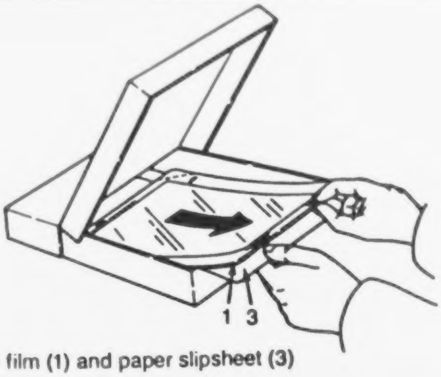
Figure 2-3A. How to image preframed film for infrared copies

How to Operate

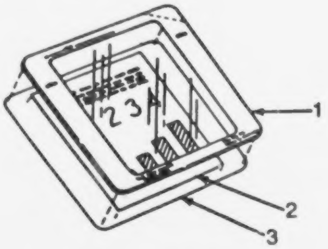
Preframed film



1. Adjust exposure knob

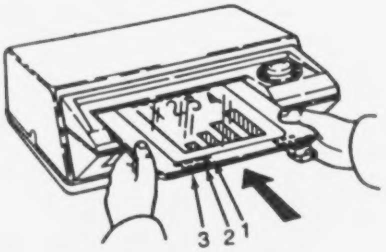


2. Remove film (1) and paper slipsheet (3) from box



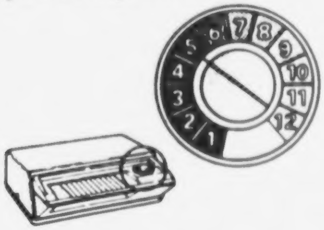
3. Arrange material: film (1), original (2), paper slipsheet (3)

Note: Remove all paper clips, staples, and pins from your original.

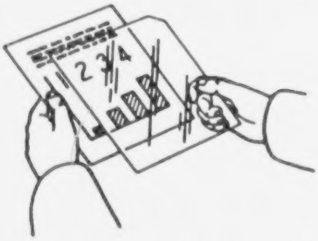


4. Insert material

Transparency film

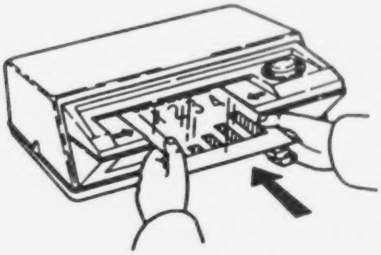


1. Adjust exposure knob

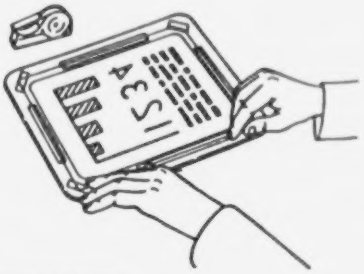


2. Place film on original (notched corner in upper right-hand side)

Note: Remove all paper clips, staples, and pins from your original.



3. Center material and insert



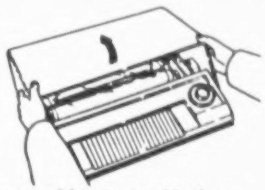
4. Frame transparency

Figure 2-3B. How to operate.

How to Maintain

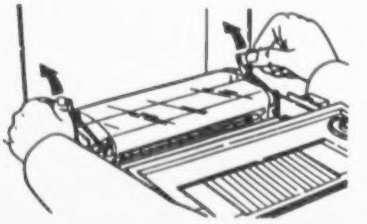
How to clean belt

Note: The cabinet may be cleaned with a mild detergent and water. The use of chemicals or solvents may damage the finish.

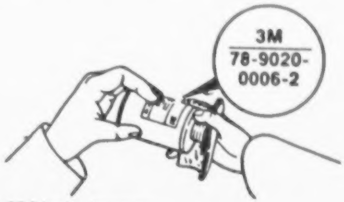


Caution: Allow machine to cool before unplugging.

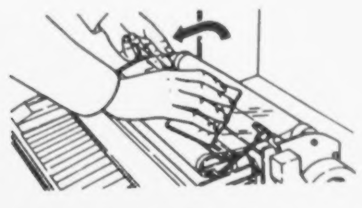
1. Unplug machine and raise cover.



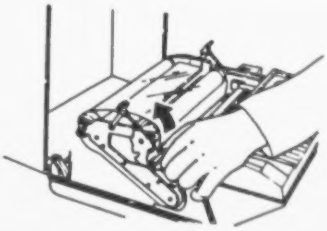
2. Allow lamp area to cool.
Lift belt latches simultaneously.



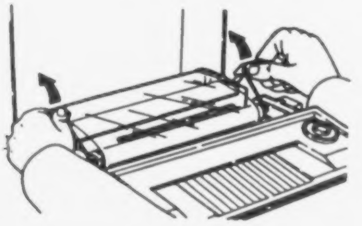
3. Apply 3M belt cleaner (78-9020-0006-2) to soft, lint-free cloth.



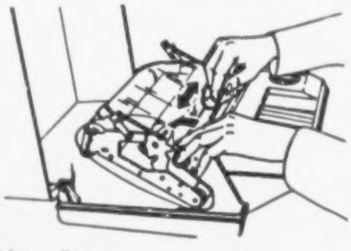
4. Rotate belt and clean entire surface.



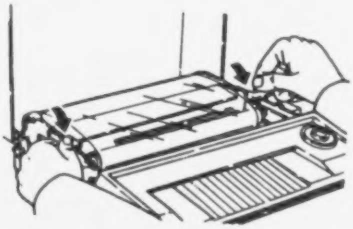
5. Lift red latch.



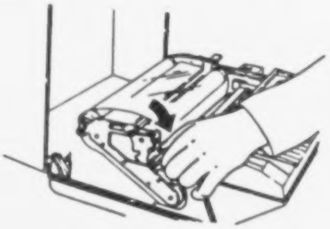
6. Raise belt latches.



7. Clean shiny roller.



8. Center belt between alignment marks. Close belt latches simultaneously.



9. Lower red latch.

Figure 2–3C. How to maintain.

Exercises (405a):

1. From what type of material can you produce a transparancy using the Thermofax process?

2. Describe the four steps in the operation of a Thermofax copier.

3. How should the film be placed over the original?

2-2. Direct Projectuals

A direct projectual slide is a visual aid that is shown directly onto a surface by a projector. The most common direct projectual used today is the 35mm-slide transparency.

406. State advantages, disadvantages, and layout procedures for 35mm-slide production.

35 Millimeter Slides. The 35mm slide has many advantages, but the greatest asset is size. The overall size of the slide is 2¼ by 2¼ inches. When placed in a projection tray, it can hold up to 100 slides safely and with ease. Entire briefings can be carried in an attache case. The small size of the 35mm slide also makes storage less of a problem.

Another advantage to using 35mm slides is their verstility. They are readily adaptable for a wide variety of visual effects. Color, 3-D, reversals, and drop-shading are just a few effects that may be used in the production of artwork for 35mm transparencies. The possibilities are unlimited.

Size, which is an important limiting factor when making view graphs, is of little concern when producing 35mm slides. Since the height-to-width ratio of the slide is 2:3, the size of your artwork can be any dimension from 2 by 3 to 40 by 60 inches, as long as it stays at the 2:3 proportion. The maximum and minimum sizes of your artwork is determined by the focusing capabilities of your photographic equipment.

The disadvantages of 35mm-slide production are few but sometimies critical. The greatest disadvantage is the time necessary for the actual production and processing of the slide. You have to consider the actual amount of time needed to produce the artwork, photograph the artwork, and process and mount the slides.

Corrections are difficult and time consuming to make. Sometimes it may even be necessary to redo the entire artwork. Careful and exact proofreading by the quality control NCO and the project officer is a must!

Since 35mm transparencies are made by direct photography, layout is relatively simple. The expression "what you see is what you get" is a rule that you can't neglect. You just place what you want on a background underneath a camera and take a picture of it. The overall process is a bit more sophisticated. There are a few principles that you must remember when you lay out your artwork; here a few guidelines:

a. Always keep your work in a 2:3 format. This is a standard for 35mm artwork.

b. Consult your photo lab to understand what type of system they use. Different lighting systems use different film types. Different film types have various color sensitivities, so you should ask the photo lab personnel which colors photograph true.

c. Know the size limitations of your photo system. You don't want to send flat-art to the lab that is either too large or too small to be photographed.

d. If you are using overlays, make sure they are properly registered. For obvious reasons, this is a very important consideration.

e. Allow plenty of bleed area around the image aperture. This is necessary to allow for variances in camera alignment and mounting without destroying the slide content.

f. Handle your artwork carefully. Remember that anything you can see on the artwork, the camera will photograph, and anything the camera records, the projector will enlarge.

g. Be critical! Time and money (frustration and heartache) can be saved if mistakes are found and corrected before the artwork is sent to the photo lab.

h. Make your instructions to the photographer clear and explicit. If you need to explain how to shoot a particular slide as the photographer works, do so. It never hurts to make sure the job is done correctly the first time.

i. Remember that artwork is reusable. Store it carefully and develop a workable catalog system so the stored artwork can be easily referenced and found.

Layout Procedures. Let's look at how a 35mm slide is handled from the work order to the final slide. The following steps are an outline of the production of a 35mm slide. (Refer to fig. 2-4.)

(1) You receive a work order with an attached draft which shows you what is required on the slide(s).

(2) Call the project officer or consult the person who accepted the work order to make sure all the instructions are clear and you understand exactly what is needed.

(3) Refer to your flat-art file to see if there is artwork that can be used for this job.

(4) Determine the size of your slide(s). Remember the 2:3 ratio and allow for sufficient bleed area.

(5) The job requirements will determine how much artwork is necessary and your unit standards will guide you in lettering styles and formats.

(6) Determine your apeture area and draw it on a piece of tracing paper large enough to cover the artwork. This serves two purposes: it shows the photographer what to focus on, and it protects the artwork from dirt and mishandling damage. Lay the

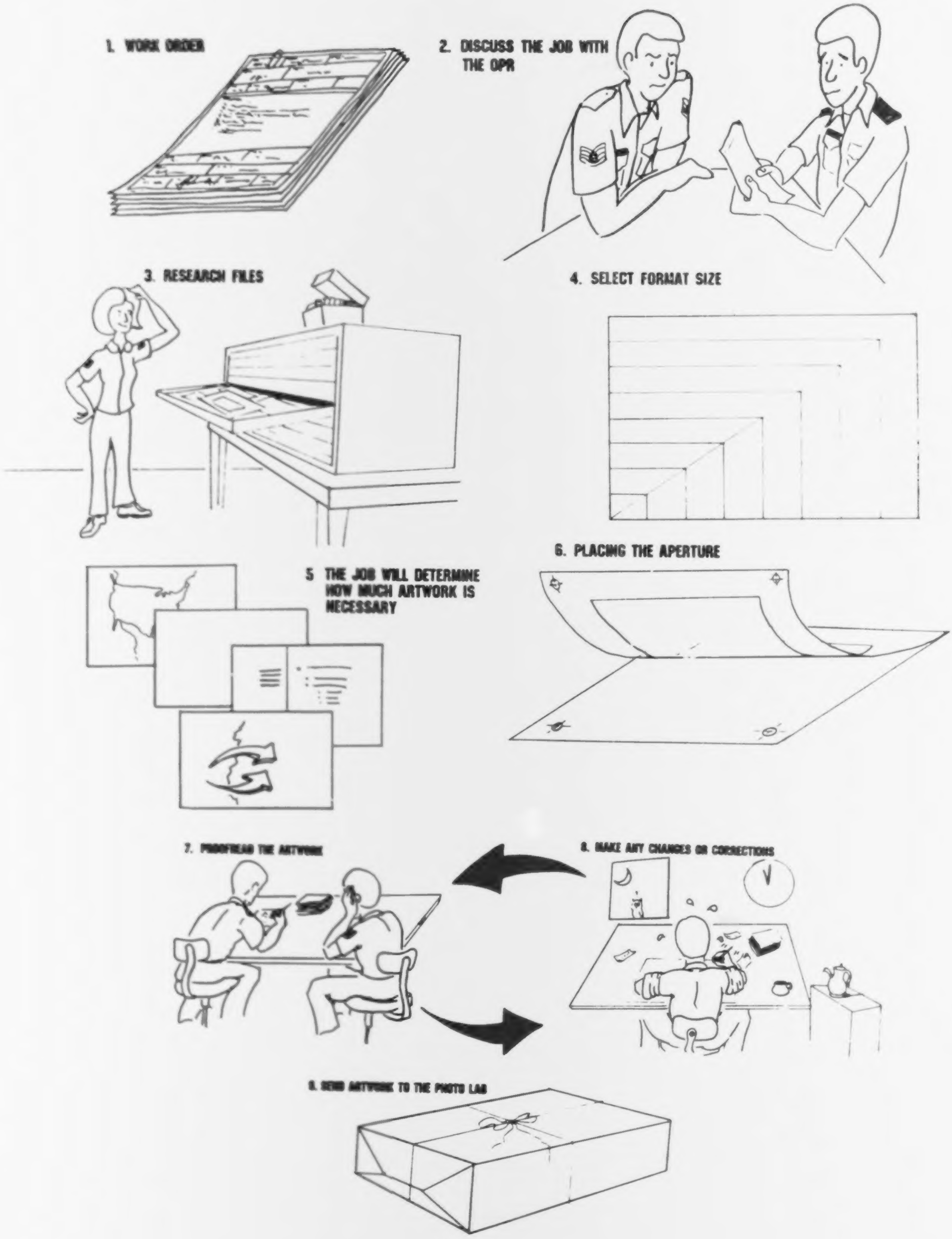

1. WORK ORDER
2. DISCUSS THE JOB WITH THE OPR
3. RESEARCH FILES
4. SELECT FORMAT SIZE
5 THE JOB WILL DETERMINE HOW MUCH ARTWORK IS NECESSARY
6. PLACING THE APERTURE
7. PROOFREAD THE ARTWORK
8. MAKE ANY CHANGES OR CORRECTIONS
9. SEND ARTWORK TO THE PHOTO LAB

Figure 2-4. 35mm production steps.

paper over the flat-art with the desired information inside the aperture. Hinge-tape the overlay so the photographer will be able to lift the paper from the artwork after focusing the camera on the aperture.

(7) Call the project requestor to proofread and correct the artwork.

(8) Make any and all necessary corrections.

(9) Send the completed artwork to the photo lab.

Exercises (406):

1. What is the greatest advantage of using 35mm slides?

2. What is the greatest *disadvantage* of using 35mm slides?

3. Why is bleed area necessary?

4. When is the best time to find and correct any mistakes?

5. Who should you contact before you start work on the job request? Why?

6. Where is the aperture area designated?

2-3. Principles of Illustrating for Television

Television is a medium appealing of two of the human senses—sight and hearing. Therefore, this audiovisual medium is ideally suited for instruction by showing while telling. Of course, the success of this medium as a teaching device depends greatly on the preparation that is made before the TV camera starts shooting. One of the area of preparation is graphic aids—the visual aids that form a large part of the props necessary to put on a program. Here is where you, as an illustrator, get into the act.

Graphic materials are used effectively in the presentation of concrete and abstract ideas in educational and informational television. Graphics include all the visual materials used to reinforce, speed, and clarify the communication of ideas, concepts, and theories.

Visual materials for television should be simple and direct so that new ideas to be presented are not lost in unnecessary detail. This last factor, closely related to legibility, is of prime importance since, without legibility, communication is lost.

In many respects, visual aids prepared for use on television require different standards of preparation than do visual aids for use in the conventional briefing room, classroom, or auditorium. Therefore, a knowledge and an appreciation of the peculiarities of television visual aids are essential for an illustrator and must be included in your training.

Since the standards of preparing artwork used to produce slides and transparencies for overhead projection are similar to those for television artwork, we have included the preparation of slides and transparencies in this chapter.

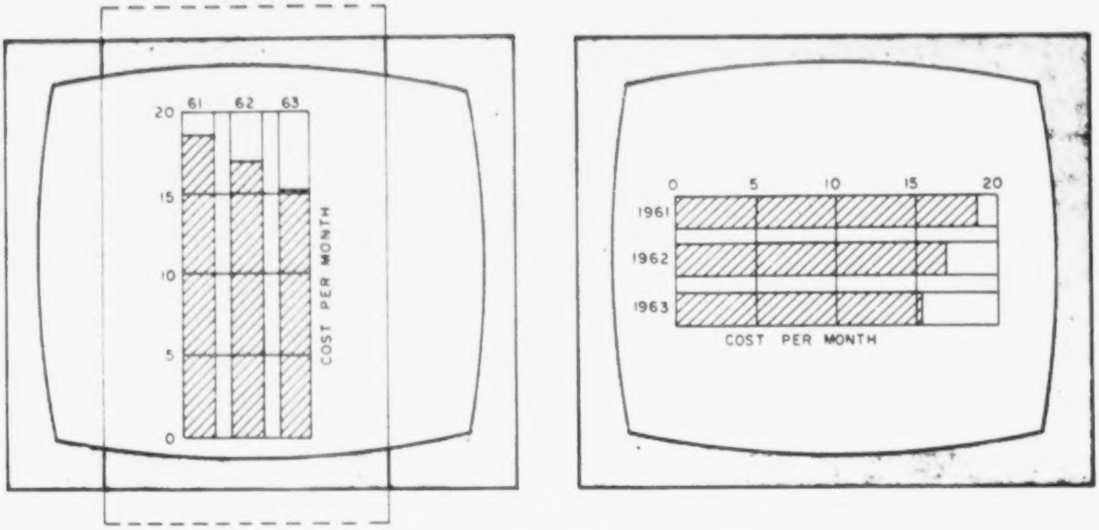
Before constructing any graphic aid, you must consider certain factors that will influence your design of the aid. Regardless of the technical excellence or informational value of the aid, if you do not adhere to certain standards of design, the aid may not be of any value, or at least its potential value may be greatly limited. This is due to the peculiarities of presentation by television. The factors you must consider are:

a. Aspect ratio.
b. Edge loss and safety field.
c. Lettering size and styles.
d. Size of graphic aids.
e. The method of checking for clarity.
f. Use of black and white.
g. Use of grays.
h. Use of color.

407. Solve problems using the aspect ratio and the one-sixth rule.

Aspect Ratio. Artwork for television must conform to the shape of the screen area of the television picture tube. The relationship of height to width, which approximates the proportion of the TV monitor (receiver), is called the aspect ratio. This ratio is 3 by 4 (3 units high by 4 units wide) and includes all components of a TV visual presentation, such as the graphic, the camera viewfinder, and all monitors. All visuals constructed for TV should have this aspect ratio to insure that all of the necessary visual material is seen on the monitor. Part A of figure 2-5 shows a visual aid with the wrong aspect ratio. Notice that in framing the aid from top to bottom, considerable blank space is left on each side. Framing the aid from side to side cuts off material at the top and bottom. Part B of figure 2-5 shows the same aid revised to the proper 3 by 4 aspect ratio. Notice that now the entire aid is on the monitor screen with no blank spaces on any of the sides and that no material is cut off.

The 3 by 4 aspect ratio has a number of merits. Probably the most important reason for using this ratio is that it is the same as employed by the motion picture



A. WRONG ASPECT RATIO

B. CORRECTED ASPECT RATIO

Figure 2-5.

industry. Thus, a televised motion picture is usually not appreciably cropped (cut off at the top, bottom, or sides). Many years ago this aspect ratio was determined to be artistically sound since it approximates the dimensions of the normal range of vision—our horizontal range of vision being about one-third greater than our vertical range.

In view of the fact that still photographs are often printed in a vertical format, one might think that much will be lost when such photographs are confined to the horizontal. There is, however, very little loss in compositional effects. In general, there is usually more interest in the horizontal direction and most motion is horizontal rather than vertical. Any graphic artwork is designed to fit within this 3 by 4 shape for maximum utilization of the picture area and correct framing by the camera operator.

Edge Loss and Safety Field. A problem closely related to the TV aspect ratio is the edge loss and safety field. The television system tends to crop the edges of all picture material. With slides, film, and artwork prepared for opaque projection, the first cropping is done by the projector. The film pickup camera and the studio camera crop more area, and finally the receiver or monitor itself makes an additional cropping. Artwork material must be prepared to keep the important subject matter within a safety field so that all of the information will appear on the receiver. Artwork prepared for studio coverage is not quite so critical since the camera operator can allow for an additional safety margin.

The one-sixth rule for determining the safe area is useful and easy to understand. As shown in figure 2-6, you divide the camera field, which is the total area of the picture, into six equal subdivisions both vertically and horizontally. The area covered by the 16 central rectangles is the safe area. A mask, corresponding to the overall size of the visual with the safe area cut out, is useful in making visual aids. You just place the mask, which can be made from paper or cardboard, on the card you plan to use to make your visual and print or draw within the cutout area.

As you can see in figure 2-6, the safety margin is quite large. This safety margin is particularly important when the camera is equipped with an image orthicon tube. The image orthicon is equipped with a safety device called an electronic orbiter that causes the picture to slowly and imperceptibly rotate. The rotation prevents the semipermanent impression of the picture on the tube, especially when bright subjects are encountered. While the rotation (1 to 2 rotations per minute) is imperceptible to the average viewer, it actually shifts the framing of a graphic when the graphic is on camera for 20 or 30 seconds. The result, in the case of an inadequate margin, is that the shot could be initially framed when it first appears and be misframed after the orbiter shifts it.

Commercial television illustrators have to make an additional allowance for monitor misalignment as to size, centering, focus, etc. In commercial television, the monitor (that is, the viewing equipment) is not under the control of station personnel since it belongs to the viewer. However, in most noncommercial TV stations the monitor is owned and controlled by the same personnel that are producing the television production. Under these circumstances, there is no reason why test patterns cannot be periodically and frequently transmitted, monitors aligned, and graphics checked out for adequacy. Thus, an extra amount of safety field need not be provided, as in commercial TV.

It is desirable that some framing arrangement be worked out between the graphic section, the camera

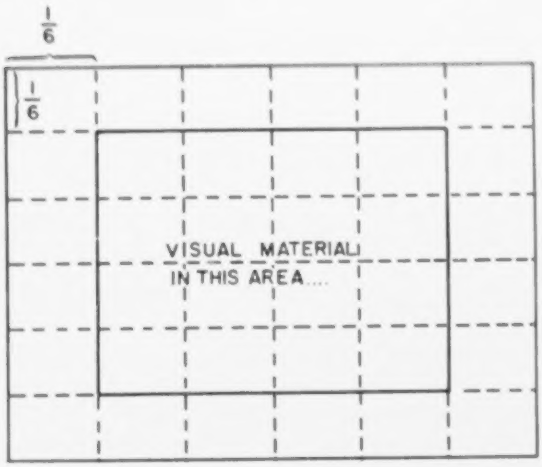


Figure 2-6. Safety field (one-sixth rule).

operator and the producers. Sometimes a graphic is confined and entirely visible within the transmitted picture. On other occasions, it is desirable to have the graphic bleed off and out of the picture area. Not necessarily knowing the intent of the particular graphic, the camera oeprator and often the director are not sure whether the entire graphic display is displayed to the viewer or whether it is intended that part of the graphic be cropped by camera framing. For this reason, a format can be established by means of sample masks to be placed over graphics, whereby the mask indicates (1) the total area to be seen and (2) the important content area. This mask is helpful to both the person operating the camera and to you. The camera operator sets up this mask on a stand and frames the camera to show the entire display area. From this point on, if the camera is not moved neither toward nor away from the graphic, the camera will have the correct framing through an entire series of graphics. Since you prepare your graphics to the same mask you can rely upon the camera operator to show the entire display area as indicated on the mask. It is common for the display area to represent the total scan of the monitor, while the graphic content area is confined to the areas of good resolution. In other words, the difference between the outer limits of the mask and the inner area of the mask excludes that area of poor edge and corner resolution. When you use this system, there is no misunderstanding between the camera operator and the illustrator as to how much of the picture to show, and there is a virtual guarantee that important and crucial graphic information will not fall into the areas of poor pictorial resolution.

Exercises (407):

1. What is the size of a full page (regular) illustration if the 3:4 ratio is maintained?

2. If the illustrating surface is 9 by 13 inches, using the one-sixth rule, what is the size of the drawing?

408. State the criterion that determines the adequacy of lettering size and styles, and apply the formula for selecting maximum letter height.

Lettering Size and Styles. Lettering size, styles, and general graphic techniques are best developed as a result of experience in your own installation. The criterion is: "If the graphic can be seen on the monitor with sufficient clarity to illustrate its point, your sizes and styles are appropriate." If the graphic is not clear, the letter style, size and/or the medium must be changed. No hard and fast rules can be stated. Each graphic organization will have to work out its own standards based upon the pictorial resolution ability of its transmission system, the basic artwork size chosen as a standard, etc. From these considerations, certain letter sizes and style will develop.

It is important that minimum letter sizes be used only when necessary in order to portray a maximum of information in a limited space. The minimum should be just that—minimum. Do not use the minimum as a standard. Whenever possible, use a larger and more clearly perceivable size of letter.

For maximum visibility, lettering for television should be simple in style. The individual characters should be consistent and clear. Complicated letter styles such as ornate and Old English should not be used because they are difficult to read at a glance. Extremely thin letters should not be used because of the possibility of losing portions of the lettering in transmission.

A rule to determine letter height has been established based upon legibility at 20 feet from a 21-inch receiver.

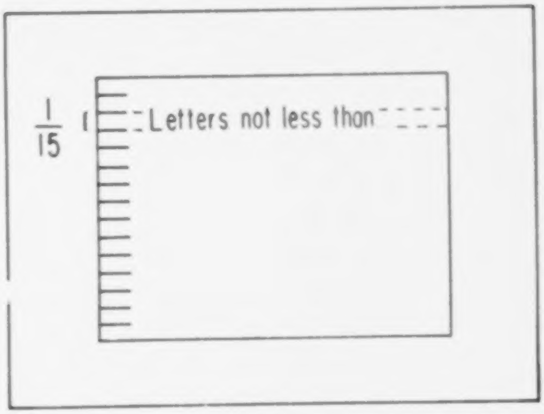


Figure 2-7. Minimum lettering height.

The rule for maximum visibility at this distance is this: "The height of the lettering should be a minimum of 1/15 of the graphic height." For example, a graphic having a vertical copy layout area of 15 inches should have letters at least 1 inch high. This minimum height rule is illustrated in figure 2-7.

Additional rules of good spacing must also be considered in television graphics. For television, the distance between individual letters should never be less than the thickness of the letter itself. Television scanning tends to cause the lettering to appear to be closer together; thus wider-than-usual spacing is necessary.

The thickness of a line, or line weight, is another important factor to consider when designing TV graphics. Based upon the above legibility standard, line weight should be a minimum of 1/75 the width of the copy layout area. The nature of the illustration and the importance of each line of copy govern the weight of the lines.

Size of Graphic Aids. We previously discussed the aspect ratio of graphic aids. However, no mention was made of the actual size. Considering an aspect ratio of 3 to 4, the graphic can be made in any size as long as this ratio is maintained. Thus, the graphic can be 3 by 4 inches, or such dimension as 30 by 40 inches, or even 9 by 12 feet. Notice that the ratio in all of the above sizes is the same. Even though the ratio is correct, you must use an appropriate size. Your problem is to provide a graphic in the 3 by 4 ratio that, when displayed at monitor size (whether this involves enlargement or reduction), is clearly visible to the viewer at the mean viewing distance.

Most TV installations select the actual size of their graphics based on such considerations as the standard stock size of illustration board, the need to file and to store, the size of the storage area, and complexity of the graphic. Naturally, you want to use a size that is comfortable to work with. Let's see why these other considerations are important.

Television gray board comes in the standard size of 30 by 40 inches. This is in our 3 by 4 ratio. Therefore, the board can be used as it is, if the illustration requires this much material and you have adequate storage room. If you use this large size, do not be misled into thinking your work is more legible than it actually is. A 30- by 40-inch illustration that is perfectly clear to you when you hold it at arm length will not necessarily be as clear to the TV viewer when looking at a 21-inch monitor at a mean viewing distance of 9 feet.

Suppose we cut the 30- by 40-inch sheet into smaller pieces for purposes of economy. By cutting the stock sheet 10 times on each edge, we obtain 100 pieces which are 3 by 4 inches, still in a 3 by 4 ratio. Obviously, this is impractical for illustrating, since much of your work would have to be almost microscopic. When the small graphic is enlarged enough to fill a TV screen, minor mistakes, bobbles, and trembles are also enlarged and are quite disconcerting to the viewer. The appropriate size, then, lies somewhere in between our two extremes.

A good, comfortable size is obtained by cutting the stock material into 9 pieces, each approximately 10 by 13⅓ inches. This size is a convenient one for you to work on; it is a convenient size for storing in standard file cabinets, and it is a convenient size for handling by personnel during the presentation of the TV production. Remember, however, that this is the size of the cardstock and that the viewing area is somewhat smaller when the one-sixth rule is applied. When possible, all graphics should be made in a single size since camera framing and focusing need to be done only once for an entire series of graphics.

Graphic art techniques, as used in television illustration, are limited by television transmission and visibility. In general, we can say that poster techniques are best suited for television illustrations. As with poster design, details and tones are so accomplished as to be understandable at a distance. Simplification of line, tone, and lettering is essential for maximum legibility.

Method of Checking Clarity. Now, let's find out how we can tell if your artwork has adequate clarity from the standpoint of the TV viewer. Assume that the size of the basic graphic is 10 by 13⅓ inches. You are working on this graphic with your eyes about 20 inches from your work. However, this distance tells you little about how the graphic looks from the distance at which a TV viewer sees it. At what distance then should you examine your work to get the same impression as the viewer? The graphic is 10 inches high but after taking off a 1½-inch border at the top and at the bottom, the space left for the actual artwork is 7 inches. If you assume that the monitor screen is 14 inches high and that it will be viewed at a mean distance of 9 feet, you can find the distance from which you must look at your illustration by the following calculations. Since 7 inches (the height of your illustration) is 1/2 of 14 inches (the height of the TV screen), you must view your illustration from a distance of 1/2 the mean viewing distance. Therefore, you should view your work from a distance of 1/2 of 9 feet which is 4½ feet.

The principle discussed in the previous paragraph pertains to all graphics and monitors; however, our example pertains only to the specific sizes and dimensions mentioned. It is important that you remember at all times that your working distance is not the proper viewing distance. No matter what size stock material you use, no matter what monitor size is used, you should continually check your work by standing back at the viewers relative viewpoint. In this way you can make sure that the information imparted by the graphic will be clearly visible.

Exercises (408):

1. If a TV graphic is 10 inches high and 13⅓ inches wide, what is the smallest possible height that lettering can be? How thin can the line weight of the letters be?

2. If you have a strip of prepared lettering that is 1/3 inch high that you want to use in a graphic illustration for TV, what is the maximum height that you can draw the illustration?

3. State the general criterion for testing style and size of letters.

409. Compare the properties of artwork for black and white and color television and the procedure for determining adequacy of resolution.

Use of Black and White. At first thought, it would seem that the use of black and white would be very appropriate for many graphics. For example, the presentation of a mathematical formula in black and white seems to be a good idea since an extreme contrast range is desirable in most illustrative work. This is not so when presented on TV. Too much contrast can cause halo and horizontal streaking when the two extremes are used adjacent to each other. Rather than black letters on a white background, a graphic having three tones such as shown in figure 2-8 would be preferable.

In general, the use of black and white in each illustration is essential. Although using black and white in every illustration may not always be appropriate from your viewpoint as an illustrator, the video engineer finds it most desirable. The video engineer sets video levels on a black-white basis. The engineer must have black and white present in the illustration in order to establish the basic video setup. Generally speaking, the difference in black and white to the video engineer is a 1-volt peak-to-peak signal. The video engineer does not consider the intermediate grays after setting the black and white levels correctly. The grays then automatically fall into their proper place. If provided with an illustration that lacks either/or black or white, the engineer has no basis for adequate video setup, and the result will likely be a poor or marginal transmission. There are cases where the deliberate inclusion of black and white, even though inappropriate to the pictorial content of the graphic, is a strained but necessary technique for the illustrator. However, this is one of the ground rules of television with which the TV illustrator must learn to live.

Use of Grays. Presuming that the television system is properly adjusted, a maximum of about eight distinct shades of gray, plus black and white, are discernible in black and white TV reproduction. Because of transmission restrictions, you must be careful how you use your gray tones. If you place two only slightly different gray tones side by side, they will probably look alike when they are reproduced on the screen. You should compensate for this by spreading your grays when making tonal illustrations. Graphics should be restricted to about three or four shades of gray (if this many are necessary) plus black and white. If you limit yourself to three shades of gray, you can use every other shade in the gray scale.

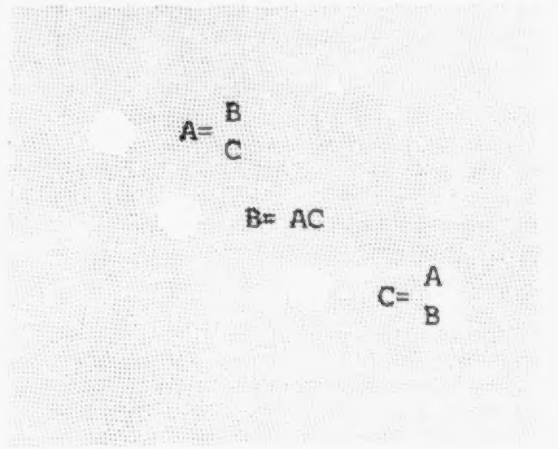


Figure 2-8. Graphic with three shades.

Use of Color. You can use color in preparing graphics for black and white TV, but you must use them with caution and only in terms of their gray scale equivalents. Two colors in a graphic show considerable contrast to the eye, but on television they may actually appear as identical shades of gray. A similar situation could develop on live TV where red chaulk is used on a blackboard. If you are in doubt about any color contrast, check the colors on camera before you go into production. Do not be misled by thinking that color somehow contributes to the graphic. It may not do so.

If you must use colors for some reason, prepare a gray response chart such as the one we discussed in the chapter on color. Relate the various colors to their gray scale values. Place the various colors and hues in columns or rows corresponding to the shade of gray in which the hue will appear on TV. Not all hues will have exactly the same gray value as the steps in the gray scale, but you can construct the columns to accommodate slightly lighter and darker readings. To construct a gray response chart, first lay out the gray scale and then make on-camera comparisons of the samples of color. Remember that the gray responses are not absolute and will vary with factors such; as lighting and camera-tube life.

Fine Detail and Resolution. To an experienced photographer, photographing the RETMA resolution target (test pattern), which is shown in figure 2-9, would be a fairly straightforward job. An exacting reproduction would show every line and every shade of gray on the target. Television reproduction does not permit a level of resolution comparable to photography. Resolution is the ability of the system to reproduce fine detail. A resolution number may be assigned by noting the maximum ability of the system to distinguish between lines of the illustrated target.

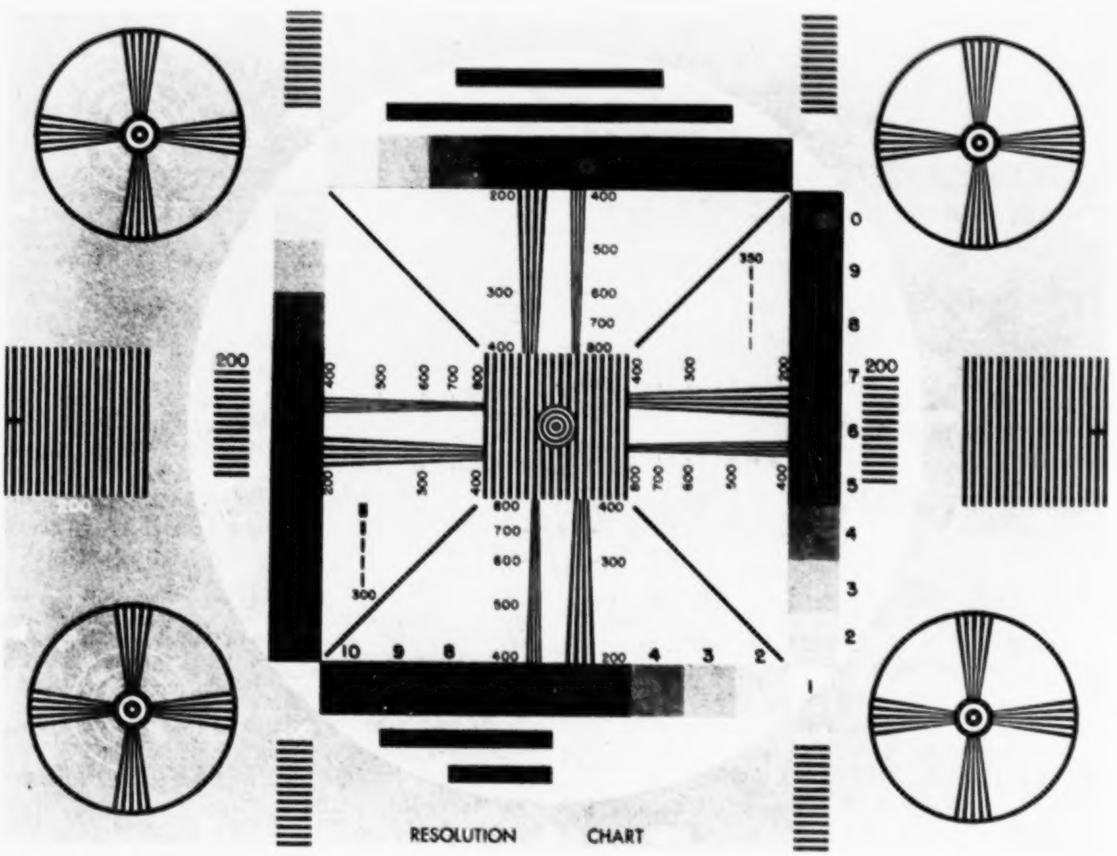


Figure 2-9. RETMA resolution target.

For example, in figure 2-9, note that the central portion shows a number of lines that taper in to a closer spacing as they approach the center of the target. One band goes from 200 to 400, and the band next to it goes from 400 to 800. By watching the monitor, you may readily distinguish a point where the lines are just barely separated. Let us suppose that the lines barely appear separated at the point marked "350." This then, is the resolution of the system at this point on the screen. This resolution would be quite acceptable in broadcast television. At the same time, you can check out the resolution at any point on the monitor by viewing the appropriate parallel bars, tapered lines, or circles. You can also check out the system with this same target by viewing the gray scale rendition.

Although closed-circuit television systems have a considerably greater capability than broadcast systems because they employ a greater number of vertically spaced scanning lines and many more video pulses per scan line, much of any fine detail in an illustration will be lost. Therefore, when you prepare an illustration for television, you should visualize it as being presented on a monitor. We have already discussed the practice of stepping back to get the same viewing ratio as the viewer. Now, here is how you can tell what your illustration will look like after loss due to the TV system's poor-resolution factor. Lay a sheet of wax paper over your illustration and step back to the appropriate viewing distance. The net result is very similar to what the TV system does to your illustration. You can save a great deal of time and effort by not including those details which cannot penetrate the TV system. A good rule to follow in designing your illustration for television is BIG, BOLD, and SIMPLE. Where details are important to the content and concept of the illustration, you will often have to develop specific TV methods.

Exercises (409):

1. What are the advantages and disadvantages of using black and white (as opposed to color) in all illustrations that are to be reproduced on television?

2. Why should you restrict your use of gray tones when designing a graphic for television reproduction?

3. If you use color in preparing your graphics for black and white television, to what factor must you pay particular attention?

4. State the general procedure to follow in determining adequacy of resolution.

2-4. Television Techniques

Since the type of illustration will depend on the particular television technique used to present it, you must learn something about these different techniques. Therefore, let's discuss several of the most important techniques—studio cards, rear projection, slides, the phantom, animation, and illustrating for color TV.

410. Associate television techniques with their descriptions.

Studio Cards. Considering the total number of visual aids used on television, most graphics are in the category of studio cards; that is, small cards placed on an easel, mounted on a pegboard, or stuck on the wall with tape, and shot by a studio camera. Since the cards are used for static presentations, they permit careful framing, lighting, and camera portrayal. In addition, they allow the narrator to point to and discuss various aspects of the graphic.

Media used in constructing studio cards are tempera, retouch grays, airbrush, grease pencil, pencil, pen and ink, felt-point pends, and pastels. Matte-finish texture sheets and matte-finish tapes are also very effective for making studio cards. Photographs that are not glossy make excellent studio cards when mounted on a cardboard backing.

It is possible to subdue a portion of the graphic, where three or more ideas are presented at the same moment, by using a tracing-paper overlay with a cutout revealing the area in which you are interested. The areas under tracing paper are subdued, but visible. The most clearly visible area and the one that the viewer will focus on is the area not obscured by the tracing paper. As the concepts develop, the original tracing paper can be modified or removed entirely. Studio cards have the main advantage (as compared with slides) of being in the studio with the narrator and under the direct and immediate control of the cameraman, the floor manager, etc.

Rear projection. In studio production, transparencies are often projected on the backside of a translucent screen and picked up by the studio camera. The transparencies normally used are the 2- by 2-inch slide and by the 4- by 5-inch cell.

There are three important advantages to rear projection. First, a projector with its associated cables does not clutter up the studio set and inhibit camera movement. Second, the studio light falling on the screen does not deteriorate or wash out the projected picture from the rear projection as it does with front projection. Third, the performer may work close to the projected picture with no worry about blocking the light from projector to screen.

The artwork for rearview transparencies can be produced in number of ways. For TV use, the photographic negative or positive is satisfactory. The original artwork is constructed keeping the standards of legibility in mind; then the artwork is photographed and reduced to a 2- by 2-inch or 4- by 5-inch transparency. Next the film is mounted in a frame and made ready for rear projection.

Another type of rear projection uses not screen. A large acetate transparency such as the ones used in overhead projectors is placed on a transparency box and ;is lighted from behind. The camera actually shoots the rear-lighted transparency.

Slides. One of the most versatile ways of displaying visual material on television is by the film-camera chain. This piece of equipment projects transparent visuals, slides, and movie film directly into a camera. By use of the multiplexer most studios can handle several sizes of slides as well as 16mm sound films. The most important display feature of the film chain multiplexer arrangement is the ability to switch quickly from slide to slide regardless of size.

The slide is presented in either positive or negative form. In the positive form it functions as a studio card; however, the narrator cannot point since he would interfere with the projection of the image. The slide used in the negative form can be used as a superimposition (super). The information on the slide is superimposed over a live scene. The lettering plus the live scene appear together. Supers usually are presented on the lower one-third of the TV screen; however, they may be planned to be inserted in any area of the picture.

The original graphic can be used directly on camera just eas easily as a slide; however, using a slide has certain advantages and permits certain specific applications. One advantage (for the director) is that the use of the graphic in slide form involves a film chain and does not tie up one of his studio cameras. However, to use a slide when a studio camera is readily available introduces an unnecessary photographic step into the process and a correspondingly unnecessary expense. The use of slides rather than the graphic itself on the studio camera is justified if the graphic is repeatedly used during the program. In live programming, cards suffer studio damage and loss, and they are a filing and storage problem. The use of slides in these cases will protect the graphic through repeated use and simplify storage and filing procedures. In a single instance of recorded programming, the principal justification for the use of slides is to free a studio camera for other use.

The Phantom. The principle of the phantom is based on color values. To use this technique, you draw the illustration on a medium gray background in colored media, preferably pencil. You must use a color that has the same value on the gray scale as the background material. As a result, while your basic drawing is visible to the narrator or instructor, it is, in effect, invisible to the TV camera. The narrator or instructor, using a felt-tipped pen or grease pencil, traces over the colored drawing visible to him. To the TV camera, he appears to be making a completely new drawing on a blank background. This approach has several uses and advantages. For example, when it becomes necessary or desirable to develop a complex graphic on camera, the drawing problems involved are vastly simplified for the "on-camera artist." He merely has to trace. This technique gives the impression that the on-camera performer is not only a competent instructor but that he is also a good illustrator. This phantom technique can also be used in the development of mathematical problems as a convenient means of preventing innocent errors that sometimes occur regardless of the on-camera performer's competence.

The phantom can also be used as a deliberate slowdown device. That is, it provides "on-air" development of a graphic that would otherwise have to be shown instantly in total form. A slowdown is desirable since it is entirely possible to present so much material at one time that the viewer can neither absorb nor comprehend.

Since the phantom is used in the studio on the set and is frequently shown along with the narrator, it should be fairly large. A convenient size is 15 by 20 inches, but it can be larger than this. For studio utilization, the phantom is placed in a frame. For live, single-instance programming, the phantom can be used directly; but in repeated or recorded programming, it is best to place it behind a sheet of nonglare glass. This procedure is wise in any event because it is possible to make an error in rehearsal.

Animation. Special techniques of presentation have been developed to create interest on the part of the viewer. One of these is animation. Since moving objects attract, hold, and lead the eye, movement or animation can be a very useful tool in aiding the learning process. Animation techniques range from the simplest movement, such as exposing a line of lettering to the most complex animation used by the television and motion picture industry. Full animation techniques are complex and require a great deal of time and expense. Since it is expensive, it is usually confined to instances of absolute need for ideal portrayal.

In 16mm motion picutures every second of animation requires 24 separate drawings since this is the frame rate of 16mm film. In television the frame rate is 30 per second. Since it is difficult and expensive to match the quality of animation produced by the motion picture industry, in television the term "animation" is generally understood to mean a limited form of animation with jerky motion and abrupt movements.

Slide card. For limited budgets, animation techniques have been devised that can be constructed quickly and inexpensively. The simplest animation technique is the slide card. It can be used to develop such things as a line on a graph, expose a waveshape, or progressively show lines of lettering. The slide card is basically composed of three layers. The top and bottom layers are stationary, and the center layer is movable. Information to be exposed is placed on the bottom layer and is covered by the center movable layer. The top layer has cutouts through which the information on the bottom layer is exposed when the center layer is removed.

Pop-in. From a practical viewpoint, animation in television is probably best limited to the step-by-step development of specific graphics by means of the "pop-in" technique. Using this system, an illustration will be shot in an incomplete form, up to a selected point. From this point on, the illustration with an addition will be edited to the previous segment. The use of either physical or electronic editing gives the viewer the impression that the additional item has just "popped in" to the basic graphic. This system can be used successfully and repeatedly—that is, a 5- or 6-segment graphic can be built up in steps by pop-ins.

Technamation. This is a technical method of limited animation that uses polarized graphic materials in conjunction with polarized light. The graphic materials for technamation have a pressure-sensitive adhesive backing and are available in various forms and shapes that produce a variety of effects. A typical use of a technamation graphic can be seen on some news and weather shows on TV. By using the appropate technamation material in an area where movement is desired, the illusion of directional, circular, or concentric motion is obtained. In addition, a blinking effect is also obtainable.

When polarized light from some source strikes a graphic, the light is reflected as unpolarized light from all areas except where the technamation material is placed. Here, it is reflected as polarized and unpolarized, enters the camera lens, there is no effect. However, if a transparent disk is slowly rotated, the reflected (or transmitted as the case may be) light from the technamation material selectively goes from matched polarization to cross polarization. At the cross-polarization position, no light enters the camera. Then gradually as the disk approaches the position where polarization matches, more light enters the lens. The net effect is a blinking area where the technamation material is located. There is no blinking from the rest of the graphic because it did not reflect polarized light.

The technamation process can be used with considerable effectiveness in many instances where action is purely repetitive. There is no long-rage effect. Whether the motion is band motion, circle expansion, flashing, etc., it is cyclic according to the rate at which the polarizing disk is turned.

Technamation material may be lighted from either the front or the rear. In the case of rear lighting, the graphic must be cut in the areas of the technamation material. Depending on the application, the polarizing disk may be placed over the light source if a single source is used or it may be placed in front of the television camera lens. The technamation principle may also be applied to fade-ins, fade-outs, color changes, or other effects, usually through manual operation of the disk.

Crawls. Another animation technique is accomplished by the the use of crawl devices. A crawl device can show a great deal of information progressively without losing continuity. Information is made to crawl or to move either in the horizontal or vertical direction across the screen. Vertical crawls are used far more often than horizontal ones.

There are a number of devices used to achieve crawl movement. One such device is the drum crawl, which is composed of a large cylinder approximately 48 inches in circumference and mounted on a rod. Information is attached to the the circumference of the drum. As the device is turned, the information moves. On the TV screen the information comes into view on the bottom and disappears at the top. Because of the curvature of the drum the copy represented has the illusion of rolling in and out. The center line of copy is distinct while the lines of copy above and below the distinct line are foreshortened and slightly out of focus.

Another crawl device is the roller crawl. It is composed of two rollers separated by a distance of approximately 36 inches. One end of a roll of paper is attached to the top roller and the other end is attached to the bottom roller. In the upright position, the information on the paper moves from the bottom of the screen to the top of the screen and is often presented as a superimposition at the beginning or end of a program. When the device is laid on its side, the information can be moved from the right side to the left side of the screen or from the left to the right, creating some interesting effects.

Gobo. A "gobo" is a graphic used in conjunction with the crawl device. the gobo is a two-dimensional cutout that is part os a complete graphic. It is mounted in front of the crawl device, and the cutout area of the gobo is registered with the information on the crawl. As the crawl information moves, it appears in the cutout window. A cartoon character holding a picture frame and information moving within the frame is an example of a crawl and gobo combination.

Illustrating for Color TV. As color TV becomes more prominent and monochrome TV gives way to some extent, your job will be lightened considerably. One of the greates burdens for monochrome TV graphics is the limitation of an absolute range of 10 shades of gray and a practical range of 4 or 5 shades of gray. Many of the most challenging problems can be easily solved when you are permitted to use color. With color, however, the use of the phantom becomes impractical as a graphic form. There are a few things to remember when illustrating for color TV. As with black and white TV, keep your size and proportions is the proper format and keep your illustration as big, bold, and simple as possible. Too much detail will be lost in the broadcast, and too much detal will clutter your drawing. Make sure your chosen colors have contrasting gray scale values, this will allow your illustration to be seen clearly on black and white TV monitors.

Exercise (410):

1. Match the items in column A with the most appropriate statement in column B.

Column A

____ (1) Slide card.
____ (2) Animation.
____ (3) Studio cards.
____ (4) Pop-in.
____ (5) Technamation.
____ (6) Rear projection.
____ (7) Phantom.
____ (8) Slides.

Column B

a. Most used form of TV graphics.
b. Uses transparencies that are 2 by 2 inches or 4 by 5 inches.
c. Most versatile display method because the original can be used directly on camera.
d. Principle based on color values.
e. Requires great deal of time and expense.
f. Simplest animation technique.
g. Gives the viewer the impression that an item has been suddenly added to the graphic.
h. Animation technique that uses polarized light.

CHAPTER 3

Printed Materials

THE ART OF PRINTING is based on a very simple principle. If you ink the tip of your finger and then press it on a piece of white paper, you will make a fingerprint—a printed image of the pattern of lines on your finger. Printing can be that simple or it cn be as complex as producing hundreds of copies of a multipage technical order; of course, printing is usually somewhere between these extremes.

But simple or complex, there must always be something to print from—something to serve as a pattern of the thing to be printed. You cannot make a fingerprint without a fingertip, nor can anything else be printed with printer's ink on paper unless there are forms of type, engraved plates, blocks, cylinders, or something to print from.

Typesetting, engraving, and platemaking are not mechanical in the same sense that printing is. They are processes and methods for creating printing patterns that can be used by the printing presses to reproduce words, designs, or pictures in small or large quantities. They are extremely flexible and versatile, for they make it possible to put in print any combination of words, characters, and figures in any language; or to reproduce any design, picture, or other graphic form in either black and white or in color.

3-1. Printing Processes

There are three basic methods of printing, and each has its own peculiar requirements as to the way its printing plates are made. These three printing methods are letterpress, intaglio, and lithography.

Gutenberg's process, known as letterpress or relief printing, is still the medium most commonly used. But looking directly over its shoulder is a newer process—one in which the printing is done from a flat, metal plate through the use of chemicals. This process is called offset lithography. There is still another process, known as intaglio printing, which utilizes an image that is engraved or etched below the surface of the metal plate. Figure 3-1 shows the principle involved in each of these printing processes.

411. Correlate printing methods with their distinguishing features.

Letterpress Printing. Letterpress printing is done entirely from raised surfaces such as type and cuts. As you have just seen, type consists of raised letters cut on blocks of wood or cast on metal shafts. These letters are set or grouped together to form words and lines. The raised surfaces of the letters are then inked and pressed against a sheet of paper to make a print or impression. (See fig. 3-1) Most newspapers and magazines are printed by the letterpress process.

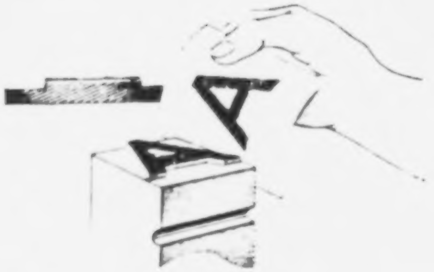
Intaglio Printing. The intaglio printing process is exactly the opposite of letterpress printing. In this process, the letters or designs to be printed are etched below the surface of a metal plate. When the plate is inked, the etched areas form tiny reservoirs of ink. The surface of the plate is then wiped clean so that when paper is forced against it, only the ink-filled areas reproduce. (See fig. 3-1.)

Engraved stationery, paper money, and postage stamps are reproduced by the intaglio process. Rotogravure is also a form of intaglio printing. The magazine section of many of our Sunday newspapers and parts of mail-order catalogs are printed by the gravure process.

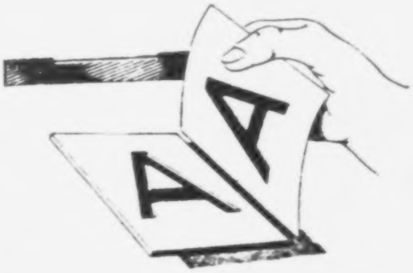
Lithographic Printing. LIthography is another important printing process. It is also known by such names as planography and photo-offset. This type of printing is different from either letterpress or intaglio printing, yet the results produced are similar. In lithogrpahic printing, the design is either drawn by hand or reproduced photographically on a flat, metal plate.

As you can see in figure 3-1, the design is neither raised nor sunken. It is the same height as the blank, nonprinting areas around it. This perhaps leads you to wonder why the nonprinting areas don't ink up along with the image when the plate is put on the press. They undoubtedly would, if they were not chemically treated to repel the ink. As a result, only the image takes the ink and the nonprinting areas remain clean, showing up on the paper as white space.

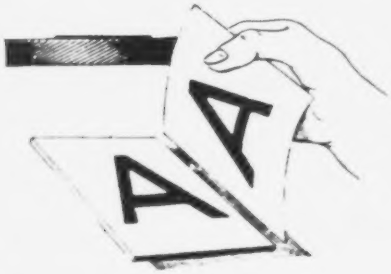
The lithographic process utilizes the principle that grease and water have no affinity for each other. In lithographic platemaking, the image eventually to be printed is affixed to the surface of the thin metal plate in the form of a thin film of greasy ink. In other words, all printing elements have a greasy surface. The spaces between are dampened with water. The ink used in this process is also somewhat greasy. When the ink is



Letterpress printing consists of pressing paper against a raised inked letter. Since only the raised surface of the letter takes ink, the low areas do not print.



Intaglio (pronounced in-tahl-yo) printing consists of pressing a sheet of paper against a plate having etched-out areas filled with ink. Although the surface of the plate inks up during inking operations, it is wiped clean before each impression so that only the etched-out areas print.



Planographic printing consists of pressing paper against a flat letter (one which is neither raised nor etched below the surface of the plate). Only the letter inks up, because the nonprinting areas of the plate are chemically treated to repel the ink.

Figure 3-1. Comparison of the three main printing processes.

applied to the finished printing form, it sticks to the grease image but is rejected by the water.

The nonprinting areas of a lithographic plate have no ink on them (because they have been dampened with water and consequently refuse to accept ink). The water on the plate, as well as the ink, must be replenished after each impression. Lithographic presses therefore have two sets of rollers, one for the ink and the other for water.

The grease image on the printing plates can be hand drawn, applied photographically, or made by transfers from a master plate or stone.

When lithographic stones are used, the process is true lithography. If metal plates are used, the process technically becomes planography. However, the original descriptive "lithography" still persists.

Most modern lithography is done by the offset process. A simple illustration of the process is shown in figure 3-2. The original thin metal plate is wrapped around a plate cylinder on the press, and the printed impression from this plate is transferred onto a rubber blanket wrapped around another cylinder (offset roller). This blanket, in turn, makes contact with the paper, and the ink image on the rubber offsets onto the paper. Thanks to modern improvements during the past 30 eyars, offset lithography has become one of the fastest and the most economical means of reproduction.

Exercise (411):

1. Match each technique in column B with the definition in column A.

	Column A	*Column B*
___ (1)	Based on the principle that grease and water repel each other.	a. Letterpress. b. Intaglio. c. Lithography. d. Offset.
___ (2)	Used by most magazines and newspapers, this method uses raised surfaces.	
___ (3)	The printed impression is transferred onto a rubber blanket and then prints the image on paper.	
___ (4)	Letters or designs to be printed are etched below the printing surface.	

412. Define, list, and differentiate among the processes for preparing copy for printing.

Copy. When the art editor assigns you an article for layout, you receive a package which usually contains two or three sets of copy, assorted photographs or sketches, and general layout instructions.

Look closely at the copy. You will find that one set is printed on coarse, cheap paper. This is called the gally copy. It is a proof page used to check for mistakes after the type has been set. This galley copy is used to complete your rought layout.

The other set(s) of the copy is called the slick copy. This copy is printed on good quality paper stock that has a smooth surface. This is a fine-quality copy and photographs quite well. This is used to paste up your final layout.

Layout. Copy layout and design is much like arranging furniture. You continually move the copy, titles, pictures, and border areas until you have a design that sets the mood for the article, is easy to read, and is uncluttered.

Standard formats are used for most publications. These formats are double-page-size cardstock sheets that are marked to show column layout borders, center gutter, page information, cut lines and bleed areas. These formats are usually marked in light blue ink so the layout lines will not produce on the photographic plate (fig. 3-3). Once you have your copy, instructions, and format, you are ready to start your layout.

The layout procedure is usually completed in a series of steps. These steps are as follows:

1. Get a clear idea of what is needed for the article. You should read the copy and any enclosed instructions. Look at any photographs that the author sent with the copy. Formulate some general ideas and then, if necessary, call the author and talk over your ideas.

2. Do a complete series of thumbnail sketches. You can work out general ideas and layouts at this time. Choose the best two or three thumbnails for further development.

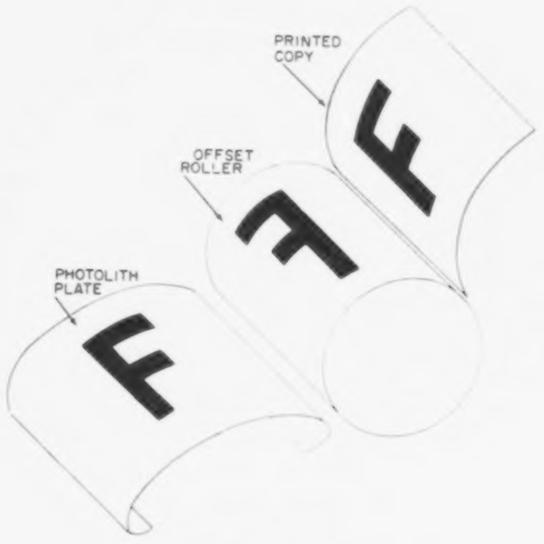


Figure 3-2. Planographic printing.

3. On a sheet of tracing paper, mark out the format that you will use for this particular layout (2 or 3 column). Use this to formalize your rough sketch. Arrange photographs, illustrations, and copy by blocking in their areas of placement. At this time, decide upon a final arrangement.

4. Using your chosen rough as a guide, develop a comprehensive. On another sheet of tracing paper, again mark out your format. Measure your copy areas and cut your galley copy. Fit the copy into the areas you have roughed out for it and tape it down. This will allow you to adjust the copy to fit evenly in the column areas. At this time, draw windows to designate areas for the photographs.

5. After you are satisfied with your comprehensive, start your final layout. Cut the slick copy as determined by your comprehensive. Adhere the copy to the format sheet by either a light coating of an adhesive or by adhesive wax. Block out the window areas for the photographs using film "ruby-lith," parapaque, or by blackening out the areas with ink or black paper. When your layout is photographed for the lithographer, the negative will show these areas as clear windows. The photos are then screened as halftone negatives and "stripped-in" the windows.

6. You are now ready to prepare the photographs for inclusion into the text. This step involves cropping, scaling, and annotating the photos so the printer will know exactly what you need done.

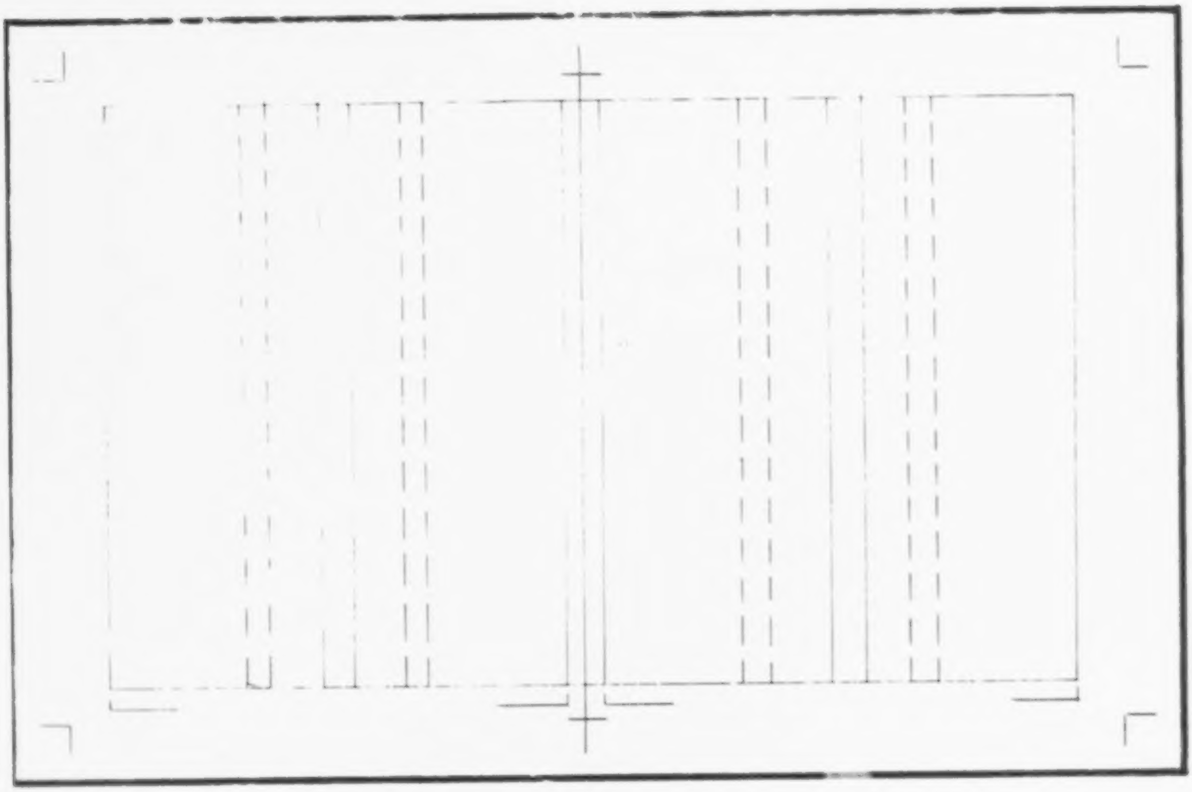
Cropping. Many times the photos that are included with the copy are not ideally suited for the layout. They may be the wrong size or contain too much unwanted image area. You can correct these deficiencies by careful cropping.

When you crop a picture, all you are doing is cutting out everything that is unnecessary to the picture content. Cropping also allows you to put the photo into the proper proportion to fit the window areas on your layout.

Cropping can be done in two ways: the tissue-overlay method or by using white opaquing fluid. Both methods do the same thing, but the tissue-overlay method doesn't destroy the photograph. No matter which method you use, always keep the cropped area of the picture in the same height-to-width proportion as the window area in your layout.

Perhaps the easiest way to crop a photograph is by using the tissue overlay. This is done by placing a sheet of tracing paper over the entire photo and, using a red marker, draw a box around the desired picture area (remember, the box must be in direct proportion to the layout window). Add dimension lines to the outside of the box and write in the desired height and width sizes. Use your proportional scale to figure the percentage of enlargement or reduction necessary and annotate this on the tissue. The note should should "enlarge to ______ percent." (See fig. 2-4.)

The second method of cropping—using white opaquing fluid to outline the cropped area of the photograph—is as effective as the first. Once you have decided upon the are you want cropped, scale it to the



LAYOUT BOARD FOR PRINTED MATERIALS

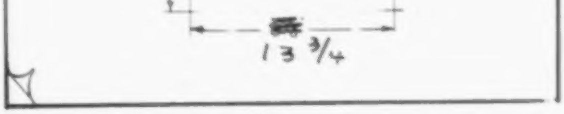
Figure 3-3.

size you need, and lightly outline the area in ink. Using white opaquing fluid or white paint, paint around the outside of the cropped area. This white border should be from 3/4 to 2 inches. Draw extension lines and dimension lines next. Finally, print in the desired dimensions of the final photo for the layout.

Whichever method you choose, make sure you give the printer complete directions as to which photo goes into which window. A simple method is to mark the windows in your layout alphabetically, also number your photos. Mark each photo where it should be placed in your layout. A typical note would read "insert photo 1 page 12 in window A." This insures that your photos are placed in the proper windows.

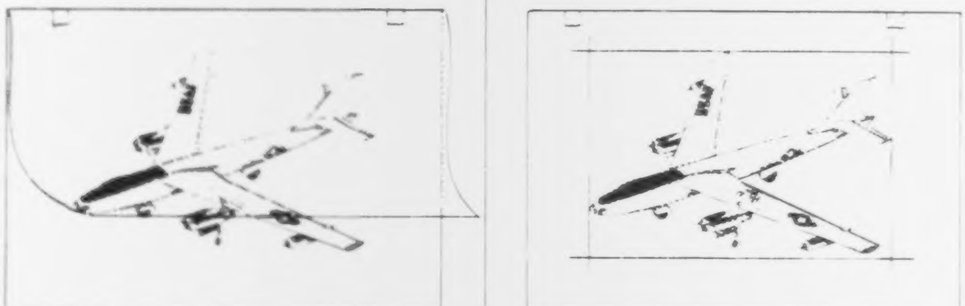
Scaling. Once you have cropped your photograph to the area you want shown and it is in the proper proportion, you must be able to tell the photographer how much to enlarge or reduce the area to be photographed. This is known as scaling. There are two ways to scale a photograph.

The first method uses a proportional scale, which will give you a percentage measurement. A percentage



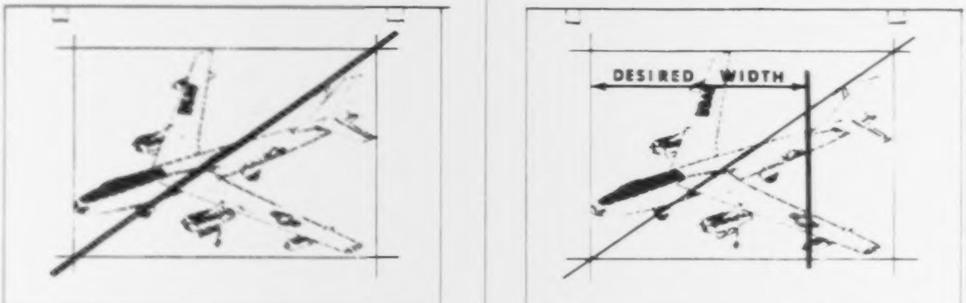
PICTURE AREA TO BE ENLARGED	1 X 2¾
PICTURE AREA IN THE COPY	5 X 8⅝
TOTAL ENLARGEMENT PERCENTAGE	365%

Figure 3-4. Photo annotations.



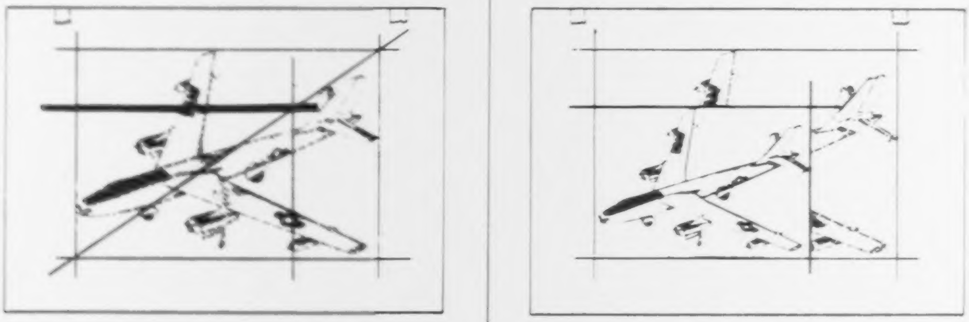
PLACE A TRANSPARENT OVERLAY OVER THE ILLUSTRATION.

ENCLOSE THE ILLUSTRATION WITH HORIZONTAL AND VERTICAL LINES DRAWN ON THE OVERLAY.



DRAW A DIAGONAL LINE FROM ONE CORNER TO THE OPPOSITE CORNER.

MARK OFF THE DESIRED REDUCED WIDTH AND DRAW A VERTICAL LINE. THE POINT OF INTERSECTION INDICATES THE CORNER OF THE REDUCTION.



A HORIZONTAL LINE DRAWN THROUGH THIS POINT WILL ENCLOSE THE REDUCED MATERIAL.

COMPLETED REDUCTION. THE HEIGHT CAN BE USED INSTEAD OF THE WIDTH, IF THE HEIGHT IS THE LIMITING FACTOR.

Figure 3-5. Reducing or enlarging method.

measurement is easier for the printer to read and makes the job a lot easier.

To find the percentage for enlargement or reduction is a simple task. Find the horizontal dimension of the cropped area of your photo on the small, inner wheel of the proportional scale (the inner wheel is marked "size of original"). Align this dimension under the under that corresponds to the dimension of the window on your layout. This dimension is located on the larger, outside wheel of the proportional scale. The percentage measurement of enlargement/reduction is then read in the window opening of your proportional scale.

Annotating. Annotate on the tissue overlay or on the back of the photo, the percentage of enlargement/reduction necessary for the photo to fit the layout. The notation should read "shoot ______ percent." The printer can then adjust the repro camera to make an enlargement/reduction of the original photograph.

The second method is shown in figure 3-5. The steps in the procedure are also given in the illustration.

Your layout is now ready for the printer. Wrap everything up carefully to protect your work during transport.

Exercises (412):

1. What is the difference between the galley and the slick copy?

2. Why is it necessary to complete a series of thumbnail sketches?

3. What purpose does your comprehensive serve?

4. What three methods can be used to block out windows for photographs?

5. What is meant by "cropping" and what are the two methods most commonly used?

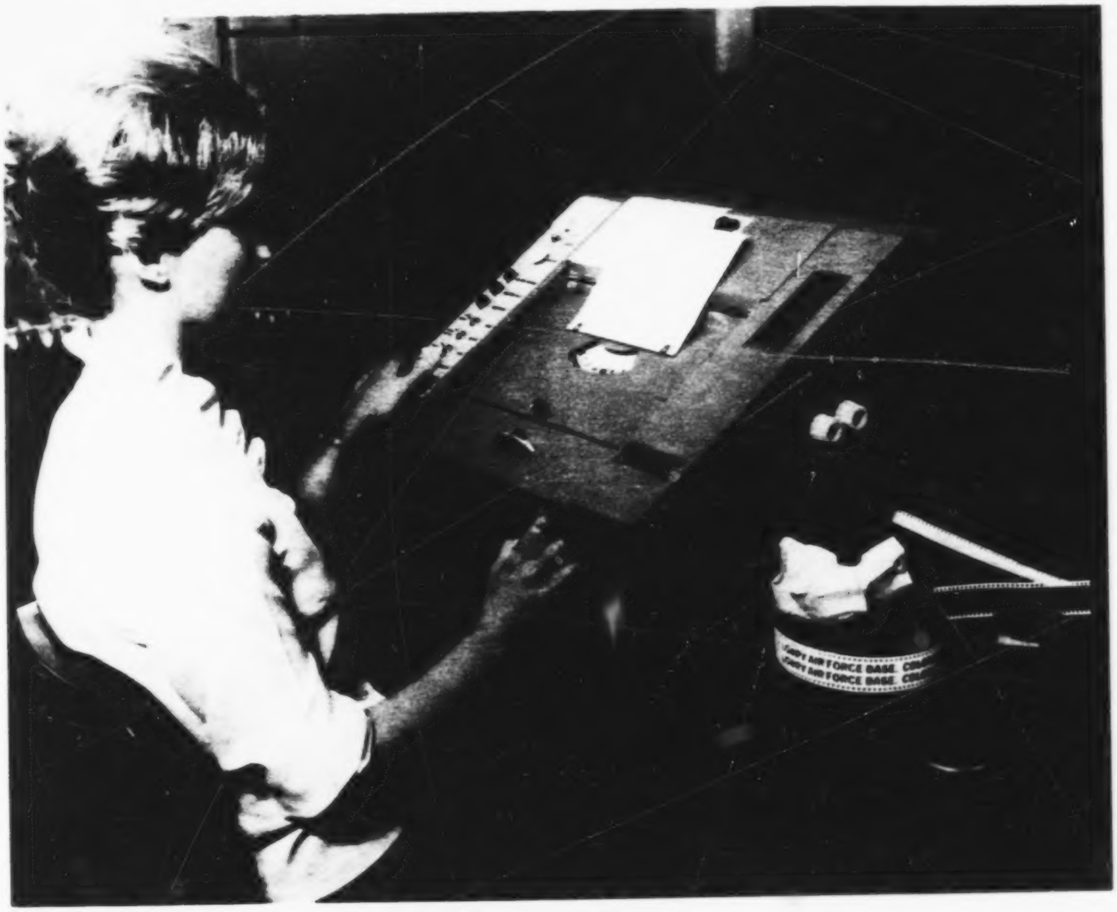


Figure 3-6. Photo before retouching.

6. How can you make sure the photographer will place the photos in the correct windows?

7. What is a good tool to use when scaling photographs for printing reproduction?

413. Explain the halftone process in terms of the procedures used.

Halftone. The printing processes that we have discussed print black and white only. We have also discussed the use of photographs in conjuction with the printing process. Photographs are seldom limited to black and white only; they also contain a full scale of gray tones. How can a printing process that prints only black and white also reproduce the tonal gray values of a photograph? The answer lies in the halftone process.

As you recall from Vol 2, you can produce tonal qualities of the gray scale using only black and white media. This is done through the use of graded line, crosshatch, or stipple line techniques.

The halftone process is very similar to the stipple technique. This process breaks up the continuous tones of the photograph into thousands of small dots. These dots vary in size and spacing so that when viewed from a distance the eye is tricked into seeing a variation of tone.

Continuous-tone drawings and photographs are "screened" to produce this dot pattern. That is, the continuous-tone photo or drawing is photographed through a screen. The screen is made of two pieces of optical glass that have parallel, opaque lines running across them. These two plates are fastened together with the lines at right angles to each other. The lines of the screen are made in various thicknesses. The width of these lines determines how many lines per inch the screen contains. The amount of lines per inch indicates the fineness or coarseness of the screen. Screens are produced in various degrees of density to accomodate the job requirements. Listed from fine to coarse, the screens are designated as follows (these are line-per-inch

Figure 3-7. Photo after retouching.

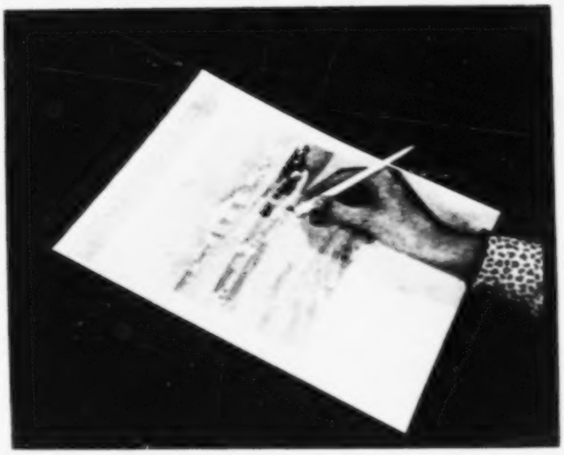


Figure 3-8. Bourges Solotone.

designations): 50, 55, 60, 65, 85, 100, 110, 120, 135, 150, 175, and 200. The lower the number, the coarser the screen.

Exercises (413):

1. Why *can't* a continuous-tone photo be reproduced on a printing press?
2. What does a screen do to a continuous-tone photograph?
3. What is a screen?
4. What determines the coarseness or fineness of a screen?

414. State the purpose of photo retouching.

Retouching. If the photographer fails to get all of the qualities that are necessary to make a photograph suitable for reproduction, you, as an illustrator, must add the missing qualities by retouching the photograph.

For example, let's look at figure 3-6. At the first glance, it appears that the photographer did his job exceptionally well; and he did, except for some things that were unavoidable or unintentionally overlooked. If the purpose of this photograph is to show how the machine pictured in the photo is operated, the reader would have to overcome some distracting influences to focus his full attention on the subject of the photograph. For instance, he might be distracted by the conglomeration of waste paper and excess film strips in the lower-right corner of the photo. The background, too, might prove distracting. It certainly doesn't add anything to the subject of the picture—the operation of the machine. Let's see how we can improve the photo by retouching it.

Look at figure 3-7. This figure shows how the photo appears after retouching. Notice that the distracting influences have been removed—the waste paper and film are gone, and the background has been subdued by placing a piece of translucent material over it. Now, let's see how this phanton effect was accomplished.

The technique that was used to subdue the background in figure 3-7 is shown in figure 3-8. The process involves the use of Bourges Solotone sheets. These sheets are specially prepared acetate sheets covered with transparent, uniformly light or dark tones that are removable. The photograph shown in figure 3-8 is covered with a white Solotone sheet. The illustration shows the covering material being scraped from the area over the part of the photograph which is to stand out clearly in the final print.

The use of Solotone is a simple process. Here are the steps you use:

1. Select the sheet that will provide the desired opacity by placing test sheets over the artwork or photo. You may want to lighten or darken a particular area.
2. Place the selected sheet (dull side up) over the artwork or photo and attach it to one side of the copy, using either plastic or making tape.
3. Remove the tone where it is not wanted. This is done either by scraping with either a plastic stylus or by applying liquid color remover.
4. Slip a sheet of black paper (or white paper if you are using dark Solotone) under the Solotone sheet to check for any areas that may not have been removed completely from the sheet.
5. After you have completed the scraping, place a protective cover sheet over the entire copy.

Exercises (414):

1. What is the purpose of photo retouching?
2. How can the background of a photograph be given a faded-out or phantom effect?

3-2. Color Separation Processes

When an illustration is to be reproduced in full color, four separate printing plates are required—a plate for each basic color. The four basic colors are red, yellow, blue, and black. This process of separating the colors may be done by the illustrator, photoengraver, or lithographer.

415. State why black is used in color reproduction and relate photoengraving processes to their descriptions.

Photoengraving Processes. The photoengraver uses filters and sensitized emulsions to eliminate the three colors not desired on the negative being made. For instance, if there is green in the subject being reproduced, the photoengraver uses a filter that allows the desired amount of yellow and blue through to those negatives and holds to a minimum the red and black in the green areas.

Indirect method. There are two basic methods that the photoengraver uses to make separation negatives. One is the indirect method of color separation, wherein continuous tone-separation negatives are made; then contact positives are made from these negatives, retouched, adn rephotographed as halftones. This method is a particular advantage with difficult copy having very dense areas that would be almost impossible for the finisher to open up when furnished with an ordinary set of prints.

Direct method. The second method of color separation is the direct method. This method is used when, in the opinion of the photographer, it is possible to make halftone color separation negatives directly from the copy. The direct method operates as follows.

The photoengraver makes screen negatives direct from the artwork by using filters. The screen negatives are then printed on metal, and the color etcher not only etches the picture into the metal but also color-corrects by etching as necessary to obtain as nearly a reasonable facsimile of the artwork as possible.

Filter principle. Color separating is subtractive and utilizes filters that are complementary to the color eventually to be used for printing. Thus, a blue-violet filter transmits blue-violet but stops yellow. This filter is used to produce the yellow printer. It works as follows.

The colors transmitted by this filter are red and blue (note that these are two of the three colors that ultimately will be used in the printing), and these are the only colors that will affect the photographic plate. When developed, these areas in the negative will be the most dense. When a print is made from this negative, the values will be reversed, the result being that the dense negative values of red and blue will be the lightest values in the print. This is the reason that it is most appropriate to refer to this as the subtractive process.

While all this is going on, the yellow of the original is being absorbed by the filter; so all yellow areas will be most transparency in the negative (consequently, most dense in the print). By subtracting the red and blue, the image of all the yellow becomes isolated or separated. When such a print is in the proper yellow, complementary to the filter color, it will represent all of the yellow in the original no matter whether it be a yellow alone or a yellow that is part of another color, such as green.

The red printer is made by following the same procedure except that a green (yellow-blue) filter is used; the blue printer is made by using the orange (yellow-red) filter.

The fourth color. It is impossible to match or duplicate a brilliant color approximating the printing ink itself, since in each case the ink absorbs such a large percentage of its own color, instead of reflecting it completely. The superimposition of all the inks full strength will not generally give a dense neutral black, but rather a greenish or reddish black, depending on whether the red or blue-green ink has the greater absorption deficiency. Hence the need for the fourth impression to give a neutral black rendering.

Illustrator considerations. The copy for process plates should be prepared with the limitations of the color process in mind. If your copy features metallic objects that are painted with metallic colors instead of ordinary pigments, you cannot expect the engraver to match this effect with process color alone. If some parts of your copy are prepared with a brilliant-chrome yellow and other areas with a pale-lemon yellow, the engraver will have to try to approximate these with process colors.

Bear in mind the difference between the texture of the drawing surface and the pages on which the print is made. Do not expect color printed on glossy stock to have the same soft feeling of watercolor painted on watercolor paper. Also, the whites of a copy cannot be reproduced faithfully when printing is done on cream-colored stock.

When you reduce a color by adding white to it, you must bear in mind that the resulting color becomes a false color photographically and cannot be reproduced faithfully. The only way that the engraver can approximate a whited-out or reduced color is to lighten the dot tone value on the inking surface of the printing plate, allowing more white paper to come through.

Color Separation Drawings. An illustrator is often called on to make color-separation drawings that the engraver or lithographer uses to make the printing plates. These drawings may be simple instructions the lithographer uses in separating the colors, or they may be the work of a skilled artist who does the job of color separation that color filters do automatically.

***Tissue overlay.* Perhaps the easiest method for the artist to use to indicate color separation is the tissue overlay. In its simplest form this method consists of a sheet of tissue (tracing paper) laid over the artwork, with the color areas blocked in with crayon or pencil. This overlay is used by the lithographer who does the actual registering of the separate pieces by adding the**

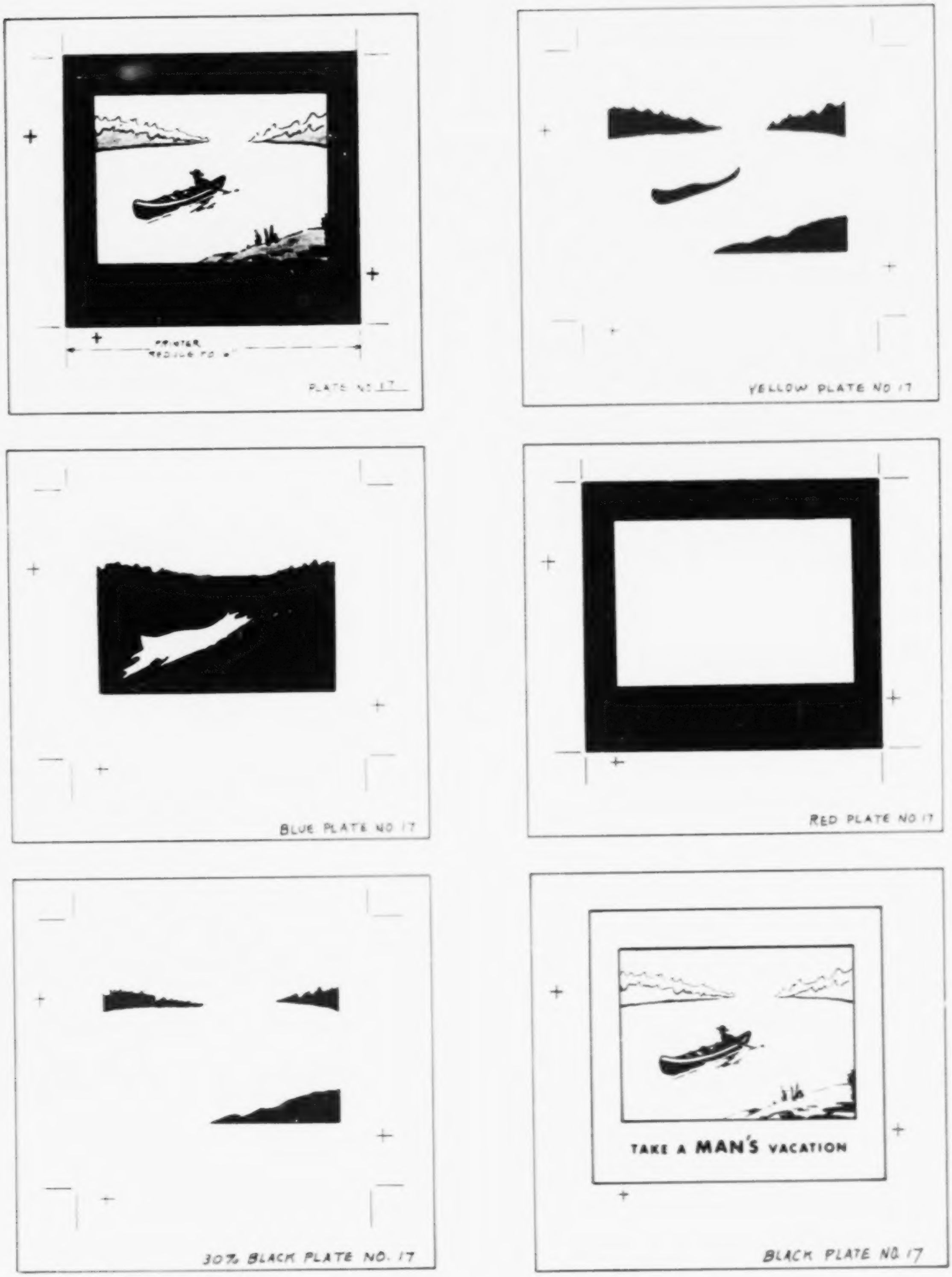

PRINTER
REDUCE TO 6"
PLATE NO 17
YELLOW PLATE NO 17
BLUE PLATE NO 17
RED PLATE NO 17
30% BLACK PLATE NO. 17
TAKE A MAN'S VACATION
BLACK PLATE NO. 17

Figure 3-9. Color-separation techniques.

lap on the film with opaque paint. This tissue method can also be used to indicate a perfect register.

Key line. This method is often used for color work with large masses. First, an outline of the color lap is drawn with a ruling pen. Then the area on the inside and the outside of this line is filled in with black, ukp to within 1/16 inch from the line. This leaves a thin white area on both sides of the design line. A tissue overlay is used to indicate the areas of color.

The lithographer makes a negative and a positive of this drawing. One is made by filling in the center and taking out the background; the other by filling in the background and taking out the center. Since the line is common to each, it forms the width of the overlap. The weight of the line depends upon the colors to be used. A set of light and dark colors can have more overlap than a set of two light colors or a set of two dark colors.

Acetate overlay. In this method the artist draws separate artwork for each color, judging, for instance, the value that must be provided on the red artwork and on the blue artwork to give the correct shade of violet when the job is printed. A typical example of the work that must be done is shown in figure 3-9.

The plate at the upper left in figure 3-9 represents the colored illustration that is to be reproduced. This plate is sent along with the others to be used by the lithographer as a guide for the finished print. Notice that it also includes three register marks, crop marks, and dimension instructions.

An acetate sheet is placed over the original drawing, frosted side up. Then the crop marks and register marks are made exactly over the original marks. Next, the areas containing the color which this plate will be used to produce are outlined and filled in with black India ink. This procedure is used for the plates of all three primary colors and for the black plate. In this particular examkple, a 30-percent black, halftone screen plate is also made, which will be used to gray some of the areas of color. This plate will be combined with the black plate in the process of making the black printing plate.

To achieve lap register, the design in each plate is made a little larger than its background to insure a slight overlap. The element to appear in the lighter color should overlap into the darker color.

Exercises (415):

1. Why is black used in color reproduction?

2. Match the most appropriate photoengraving processes in column A with the descriptive statements in column B.

Column A

____ (1) Indirect method.
____ (2) Direct method.
____ (3) Blue-violet filter.
____ (4) Lap register.
____ (5) Green filter.
____ (6) Red printer.
____ (7) Blue printer.
____ (8) Yellow-red filter.
____ (9) Neutral black
____ (10) Tissue overlay.
____ (11) Key line.
____ (12) Acetate overlay.

Column B

a. Continuous-tone separation negatives are made.
b. Used for color work with large areas.
c. Stops yellow.
d. Color areas are blocked in with crayon or pencil.
e. Placed over original drawing, frosted side up.
f. Green filter used.
g. Screen negatives made from artwork by using filters.
h. Advantageous with difficult copy (having dense areas that would be almost impossible for finisher to open up with ordinary set of prints).
i. Artist draws separate artwork for each color, judging the values to be produced.
j. Design in each plate is made a little larger than its background.
k. Used when it is possible to make halftone-color-separation negatives from copy.
l. Screen negatives are printed on metal, the color etcher etches the picture and color corrects.
m. Yellow-blue.
n. Orange filter.
o. Fourth impression.
p. Easiest method for artist to indicate color separation.

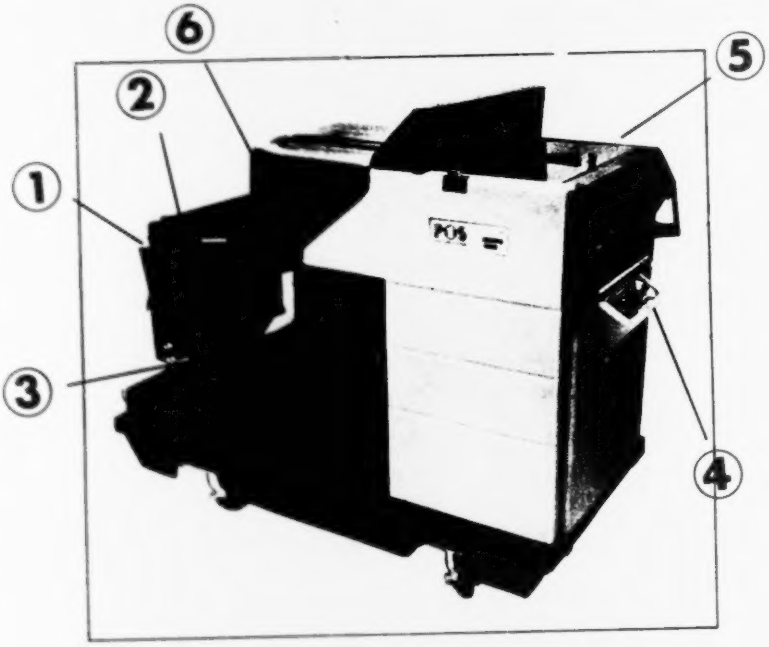
3-3. Copy Cameras

Photography is a very important part of printing; the two go together. If your unit has a large requirement for printed materials development, you may need to be familiar with copy cameras.

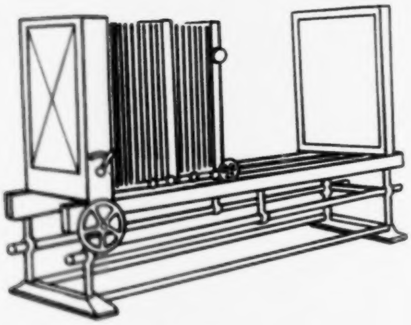
416. Identify and define the components of a copy camera.

Copy Cameras. Copy cameras are a very important part of the printing field. They are used to enlarge or reduce titles and copy, screen photographs, or produce positive or negative copy.

There are quite a few systems in use today. These include, but are not limited to, POS ONE Systems, Polaroid Systems, and the Princeton Land Cameras. Although these systems are different, they all have the same basic components. These components are the copyboard, copy lights, lens assembly, ground-glass focal plane, timer, and on some units, an automatic processor. We will look closer at these components and discuss their functions. (Refer to fig. 3-10.)



1. Copyboard
2. Copy Lights
3. Lens Assembly
4. Timer
5. Glass Focal Plane
6. Automatic Processor



MOVABLE BACK AND LENSBOARD

Figure 3-10. Copy camera.

Copyboard. The copyboard of a camera system is a flat surface upon which the copy is attached for photographing. The board itself, has a series of centering lines. These lines allow you to place the copy in the focal center of the camera. The board usually has a piece of nonglare glass that lies on top of the copy to hold the material flat and eliminate glare; some units have a vacuum board that holds the copy. The copyboard pivots flat for the placement of copy.

Copy lights. As a rule, these lights are attached to the copyboard and travel along with it. Their function is to provide strong, flat, and continuous illumination to the copy as it is being photographed. The lights are usually arc lamps, quartz iodine lamps, or pulsed xenon lamps.

Lens assembly. As in any camera system, the lens assembly plays a vital role. This assembly contains the light-controlling mechanisms that allow you to properly expose the film. This assembly contains a series of glass lenses that focus the light, an adjustable aperture that controls the amount of light, and a shutter that limits the amount of time the light strikes the film. Most cameras have an automatic focus. Usually, the only adjustment that is necessary is the aperture setting.

Glass focal plane. The glass focal plane is a sheet of frosted glass mounted at the back of the camera. The light entering the lens assembly projects an image on the glass. The image is then focused; the glass is removed; and the film is placed in a frame and inserted into the camera.

Timer. The timer is a clock mechanism that holds the shutter open and the lights on, until a complete exposure has been made.

Automatic processor. Some units have an automatic processor attached to them. This processor develops the film or print using a four-stage self-contained system. The processor keeps the developing chemicals at the proper temperature at all times. These systems are costly, but they are extremely convenient.

Exercises (416):

1. What is the function of the copyboard?

2. Name three types of lamps used in copy lights.

3. Name the parts of the lens assembly and give the function of each.

4. Which component of a copy camera is a sheet of frosted glass that is mounted in the rear of the camera?

5. What is the function of the timer?

3-4. OVERHEAD, OPAQUE and ENLARGEMENT/REDUCTION PROJECTORS

Sometime in your career as an illustrator, you may need to enlarge a picture beyond the capabilities of your camera systems. How would you reproduce an illustration large enough to cover the side of a small aircraft hangar?

The simplest method for producing oversized enlargements would be by using overhead, opaque, and enlargement/reduction projectors. In this section, we will discuss the description, controls, and maintenance of overhead, opaque, and enlargement/reduction projectors.

416a (420—for CE feedback reference only). Explain the differences in the operation of overhead, opaque, and enlargement/reduction projectors.

Description of Overhead Projector. The transparency projector we will use is the 3M Model 213 series. We will discuss a model with all the options to show the different capabilities of transparency projectors. All data and illustrations are used with the permission of the 3M Company. This projector is 15 inches (380mm) wide, 16 inches (405mm) deep, and the body height is 9½ inches (240mm). The height to the top of the projection head is 30 inches (680mm). This series of projectors weighs between 22 and 30 pounds, depending on accessories and power supply options. It has a 12 7/8-inch triplet lens system with a front surface mirror and a 10½-inch by 10½-inch stage aperture.

Controls. Refer to figure 3-11 as we discuss the following controls.

Lamp change lever. This projector has two lamps. When the primary lamp fails, turn the projector off and slide this lever to the secondary lamp position.

Lamp intensifier switch. When this switch is in the HIGH position, the light output increases 10 percent. This switch is used for special transparencies or screens that have a problem with ambient light. It should be noted that the life of the lamp is reduced by half when using the higher light output.

Optical tuning wheel. The projection lamp height can be manually adjusted by rotating this wheel on the back panel. This tunes the projector for optimal performance on different-size screens and eliminates the red and blue corners.

Lamp indicator light. This warning light on the front panel indicates when the second lamp is being used. Always replace the primary lamp before the next presentation.

Care and Maintenance. This projector, like all other pieces of AV equipment, requires preventive maintenance to insure a long, useful life. The projection lamp, lenses, and mirrors require careful handling to prevent damage. The following paragraphs will cover the basic care and maintenance procedures.

Lamp replacement. This projector uses an ENX lamp that will last about 170 hours at high intensity and 370 hours at low intensity. If your projector doesn't contain a second lamp, allow the lamp to cool for a few minutes. Next and most important, UNPLUG the power cord. Rotate the optical tuning wheel on the rear of the projector counterclockwise until it stops rotating. Push down the button which releases the access door and raise the door. Pull the lamp ejector lever toward the rear of the projector and the lamp will come out of its holder. Lift out the burned-out lamp and insert a new one, making sure to wipe off your fingerprints. Close the access door and turn on the projector. The final step is to rotate the optical tuning wheel until the image is white and has no red or blue corners.

Cleaning. The only optical surfaces that require cleaning are the outside lenses of the projection heads and the top surface of the optical stage. Clean the surfaces with a mild detergent solution and a clean, soft, lint-free cotton cloth. Do not use paper towels to clean the surfaces because they will become scratched. To avoid permanent damage to the surfaces, be sure to rinse and dry them after cleaning.

The mirrors in the body and in certain projection heads are front surface mirrors and must not be cleaned. Front surface mirrors have the reflective surface on the front of the glass. These mirrors do not reduce image brightness or clarity, which is a problem with conventional mirrors. Remove any surface dirt on these two mirrors with a camel's hair bursh only.

Opaque Projector. The projector we will use for our discussion is the Besseler Vu-Lyte III Opaque Projector. All data and illustrations are used with permission from the Charles Besseler Company. It is 18½ inches high, 13 inches wide, and 20½ inches long. It weighs about 33 pounds. It will project all opaque substances up to 10 inches. It uses a 1000-watt lamp and delivers 145 lumens on the screen.

Controls. Refers to figure 3-12 as we discuss the following operation and adjustment controls.

Switch. This three-position switch turns the projector on and off. Its middle position is for cooling.

Feedomatic and feedomatic handle. This conveyor belt feeds material in smoothly for projection. Turning the handle will move the material and center it on the screen.

Pointer widow and handle. This window projects a small arrow to emphasize any area on the screen. To move the arrow image vertically on the screen, turn the pointer handle up or down. To move the arrow image horizontally, move the pointer handle to its left or right.

Copy space lock and handle. These are used to open the carriage to project thick copy.

Elevating lock handle. Turning this handle releases the spring-loaded elevation legs and raises the screen image.

Set up. Place the projector on a projection stand or table so that the feedomatic is at a comfortable working level. Plug in the power cable and open the lens cover. Turn the switch to the ON position, insert the copy, and focus it on the screen by rotating the focus knob. Adjust the screen image laterally by moving the projector from side to side. Adjust the vertical image by turning the elevating lock handle counterclockwise. When the image is the proper height, lock it into position by turning the locking knob clockwise.

You may also increase the range of magnification by loosening the lens screw and moving the lens backward and

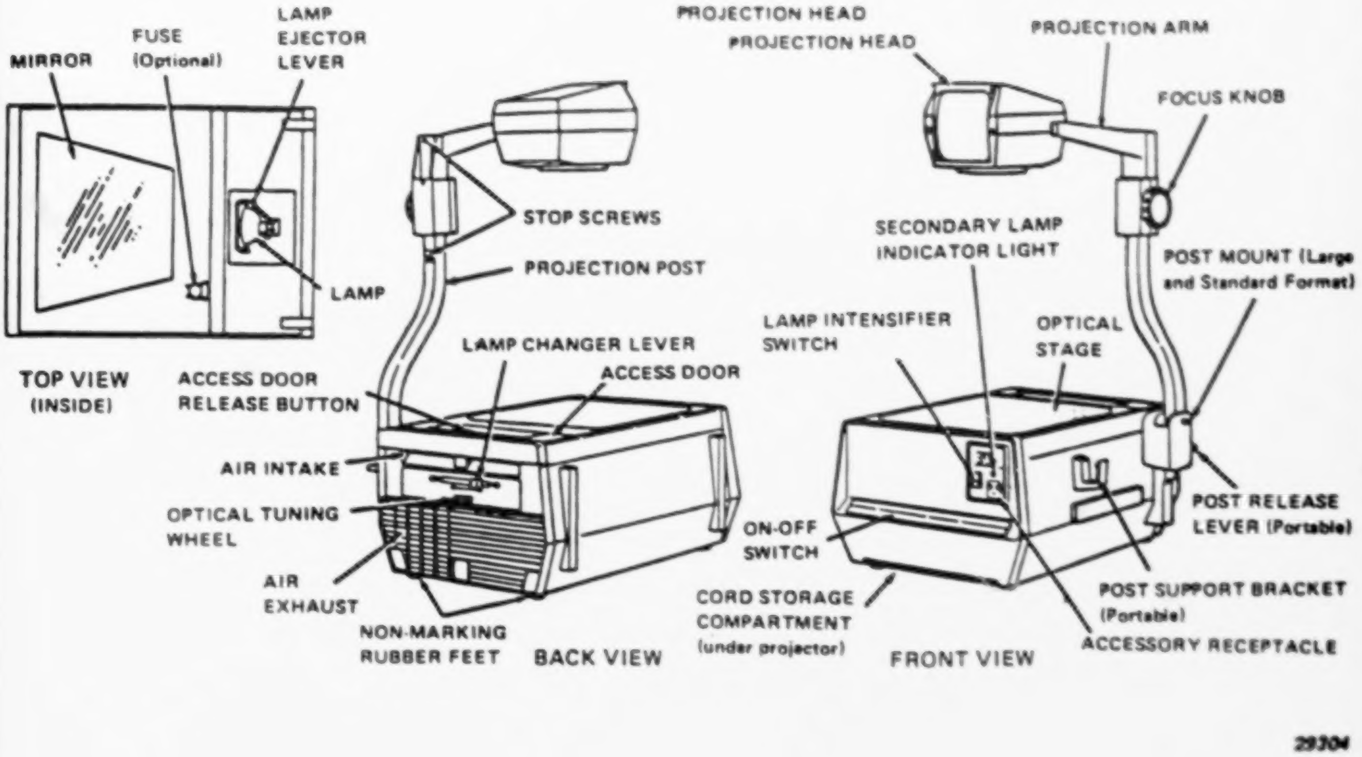

MIRROR
FUSE (Optional)
LAMP EJECTOR LEVER
LAMP
TOP VIEW (INSIDE)
STOP SCREWS
PROJECTION POST
LAMP CHANGER LEVER
ACCESS DOOR
ACCESS DOOR RELEASE BUTTON
AIR INTAKE
OPTICAL TUNING WHEEL
AIR EXHAUST
NON-MARKING RUBBER FEET
BACK VIEW
PROJECTION HEAD
PROJECTION HEAD
PROJECTION ARM
FOCUS KNOB
SECONDARY LAMP INDICATOR LIGHT
POST MOUNT (Large and Standard Format)
LAMP INTENSIFIER SWITCH
OPTICAL STAGE
POST RELEASE LEVER (Portable)
ON-OFF SWITCH
CORD STORAGE COMPARTMENT (under projector)
POST SUPPORT BRACKET (Portable)
FRONT VIEW
ACCESSORY RECEPTACLE
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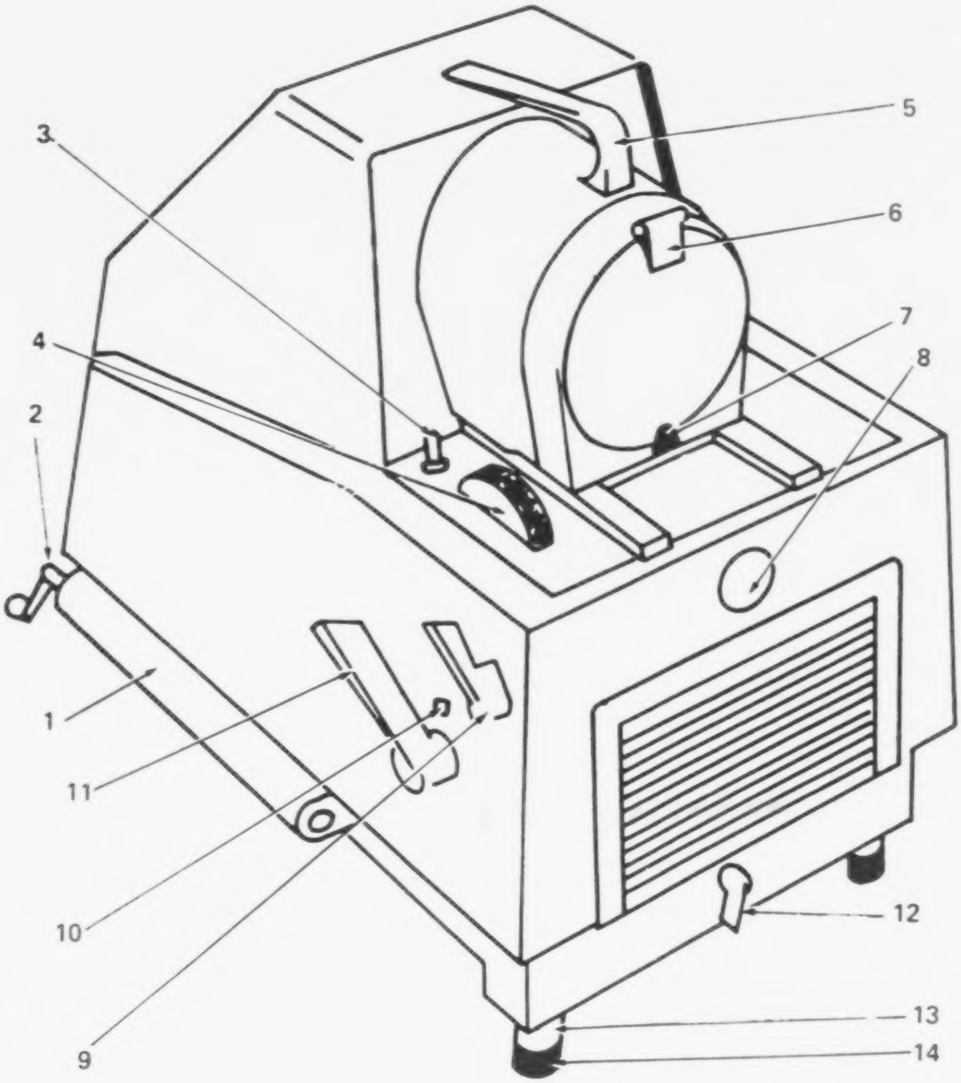
Figure 3-11. Description of overhead projector.



VU LYTE III WITH PRINCIPAL PARTS IDENTIFIED

1. FEEDOMATIC
2. FEEDOMATIC HANDLE
3. SWITCH
4. FOCUSING KNOB
5. CARRYING HANDLE
6. LENS CAP
7. CAP KNOB
8. POINTER WINDOW
9. POINTER HANDLE
10. COPY SPACE LOCK
11. COPY SPACE HANDLE
12. ELEVATION LOCK HANDLE
13. ELEVATING LEG
14. FRONT FEET

03111

Figure 3-12. Description of opaque projector.

forward. For large magnification, push the lens back into the mount about five-eighths of an inch. To reduce magnification, pull the lens out and about 1 inch.

Operation. Insert the material to be projected in the space between the projector body and the feedomatic belt with the bottom of the copy toward the screen. Center the copy on the projection stage by turning the feedomatic crank counterclockwise for right to left, or clockwise for left to right.

To project thick copy, release the copy space lock by pushing the slide button toward the front of the projector and simultaneously turning the handle. Turn the handle clockwise to increase the copy space and counterclockwise to decrease copy space. There is also an access door in the rear of the projector where you may insert oversized objects.

There are two pieces of optional equipment that you should become familiar with. The first is a glass pressure plate that lies in a built-in sliding drawer. This is used to keep such items as photos and books flat for projection. The other accessory is the heat filter. This filter is used to provide additional protection to temperature-sensitive materials or thick materials that are to be left in the projector for long periods of time.

Care and Maintenance. Simple care and occasional cleaning will keep this projector in good working order.

Cleaning of optical elements. The following optical elements should be cleaned by wiping with a lint-free cloth or lens tissue. Because the projection lens is sealed at the factory, it is necessary to clean only the external surfaces. The rear surface of the lens is reached through the rear door of the projector. The parabolic reflector and secondary mirrors are also accessible through the rear door. The most important optical element on this projector is the front surface mirror. The mirror coating is very delicate, and care should be taken not to get fingerprints or other marks on it. Remove dust with a camel's hair brush. If the mirror has been badly soiled, it may be wiped with a clean, lint-free cloth or lens tissue. This, however, will scratch the surface and should not be done unless the mirror has been badly soiled.

Projection lamp replacement. The lamp can be changed through the rear door. To remove the old lamp, push the lamp down and turn counterclockwise one-half turn. To install the lamp, align the lamp socket ears with the matching slots in the lamp socket and turn clockwise.

Motor. The motor is equipped with impregnated bronze bearings which should be lubricated with light machine oil every 6 months. The bearings are accessible by removing the front grill of the projector.

Enlargement/Reduction Projectors. These projectors are often called lucida projectors or "Lacey (Lazy) Lucies." They consist of a copyboard, a lens head, bellows, a light source, a ground glass projection plate, and a hood. These projectors are extremely useful tools for designers who want to enlarge or reduce artwork to fit a layout. The only drawback is that the projected image can be seen clearly only through tracing paper or some other translucent material. This means that the drawing must first be traced on the translucent material and then retraced on another drawing surface.

Operation. Lucida type enlargement/reduction projectors use reflected light to project an image. The ideal location for this type of projector would be where the lighting can be controlled.

The beauty of this type of projector is its simplicity of operation. The following steps outline the enlargement/reduction procedures:

1. Place the item to be enlarged or reduced on the copyboard and secure it with tape.
2. Cut a piece of translucent paper larger than the required enlargement/reduction. Tape this to the ground glass projection plate.
3. Reduce the room lighting.
4. Turn the projector lights on.
5. Standing under the hood of the projector, you can now see the image of your subject matter.
6. Bring the image to the correct size by operating the sizing knob.
7. Focus the image with the focus knob.
8. You will now be able to trace the image on the translucent paper.

Care and Maintenance. Simple care and occasional cleaning will keep this projector in good working order. Clean the glass with a soft, lint free tissue and any chemical glass cleaner. Keep dust and dirt off the copyboard. Oil the focus mechanism tracks to keep them operating smoothly. Replace light bulbs as necessary using manufacturers' specifications and precautions.

Exercises (416a):

1. What does the lamp intensifier switch do?

2. What must you do after inserting a new lamp in an overhead projector?

3. What are the only optical surfaces of an overhead projector that require cleaning?

4. How do you remove the surface dirt from the front surface mirrors of an overhead projector?

5. How should material be inserted into an opaque projector?

6. Which part of an opaque projector keeps photos and books flat for projection?

7. What is the purpose of the heat filter on an opaque projector?

8. What is the most important element in an opaque projector?

9. What is the major drawback of lucida-type projectors?

10. What is the ideal location for the operation of a lucida projector?

CHAPTER 4

Special Techniques

THERE MAY BE TIMES when you will encounter special problems in graphics productions. These problems normally deal with illustrating on unusual surfaces or producing unusually realistic tonal effects on an illustration. There are two special techniques that are specifically suited to these problem areas. Silkscreen printing is used for printing on unusual surfaces and the airbrush is used to produce realistic tonal effects. In this chapter, we will discuss the characteristics and uses of these techniques.

4-1. Airbrush

The airbrush technique of using the wash medium presents the most lifelike rendering effects of any illustrating technique. This technique can present realistic effects in tone because it is capable of producing even tones, gradual variations in value, and sharp tone contrasts. The airbrush applies wash to the illustrating surface in a fine spray which is driven by compressed air.

Some airbrushes can regulate the density of the paint spray. Others are self-regulating, and the density increases as the opening to the paint reservoir is enlarged. The width of the spray is primarily dependent upon the proximity of the airbrush to the illustration surface—the closer the instrument is held to the surface, the narrower the spray will be.

The airbrush is an excellent medium for retouching photographic prints, and it is often used to render illustrations. Such airbrushed rendering is generally made on illustration board; however, any relatively nonabsorbent surface, if mounted on a stiff board, may be used.

417. State special techniques and preparations that apply to airbrushing.

The method of applying wash paints by the airbrush technique is relatively standard. As a tool, the airbrush has limitations and operating requirements which dictate its method of use. A typical airbrush as shown in figure 4-1 applies paint in broad bands or sharp jets—either in a coarse or fine spray.

The most important requirement for rendering with the airbrush is a controlled and consistent application of paint. It is obvious that the density of the spray which reaches the illustration surface will decrease as the airbrush is moved away from the surface. Therefore, to achieve a consistent tone on a given area, the airbrush must be handled in such a way that the distance does not vary. Naturally, the size of the spray cone will vary in the same manner. Therefore, to obtain a band of tone of a specified and consistent width, the distance must not vary.

Since the very character of the spray is aerosol, it is not easily controlled by motions of the hand. Therefore, the presentation of sharply defined edges and details is aided by the use of shields or masks. A mask may be merely a piece of paper cut to the desired shape and held directly on the illustration surface. Thus, a sharp outline will be produced when paint is applied around it. The disadvantage of using a mask is that the mask temporarily obscures the area of the illustration that it covers. From the standpoint of accuracy, and the fact that nothing is obscured, a frisket or other transparent or semitransparent paper is more desirable.

Frisket paper is a special paper that is semitransparent, very thin, nonabsorbent, and easily cut. This type of mask is held or cemented directly to the illustrating surface, thus producing a sharp outline of the mask where airbrushed.

Another type of mask, or shield, is the raised mask. The raised mask is used when the density and sharpness of tone on the top and bottom of an airbrush stroke must vary. By varying the angle at which the spray strikes the mask, the sharpness of the bottom edge of

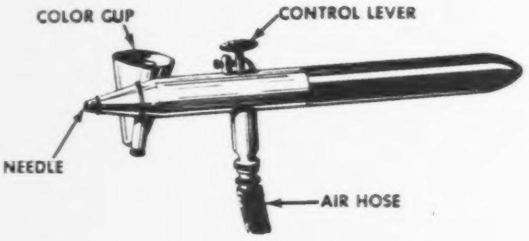


Figure 4-1. Main components of an airbrush.

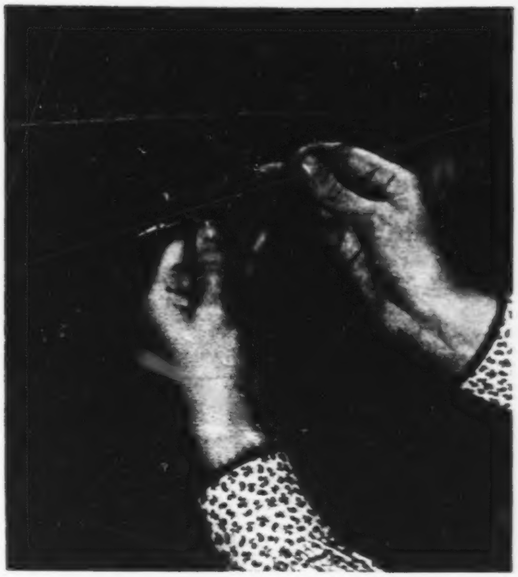


Figure 4-2. Removing or inserting the needle of an airbrush.

the tone is made to vary. Of course, the width and diffusion of the top edge is controlled by the distance of the airbrush from the paper.

An airbrush may be used with either transparent or opaque wash. Generally, the transparent wash is lampblack diluted to the value used for middle-gray washes. Tone gradations are accomplished by repeated application of paint. The tone will darken as the density of the applied pigment is increased in a particular area.

With opaque washes, tonal gradations are accomplished by the mixing of white with the black. These opaque washes are prepared in progressive values from slightly darker than white to slightly lighter than black. By diluting any one of these tones, a transparent effect can also be obtained. The transparency thus obtained can be graduated in tone value from slightly darker than white to the original opaque tone.

The methods of working in transparent or opaque media differ considerably. When working in transparent wash to render an area with strong highlights and shadows, only the darks are airbrushed, leaving the highlights. This is necessary since dark transparent pigments can only darken a white illustrating surface.

When using the opaque method, it is possible to apply a middle tone gray and then apply darker grays or blacks for shadow and lighter grays or white for the highlights. The opaque method allows more control over shapes and values. Corrections and changes can be easily made by repainting with any value desired whether the desired value is lighter or darker than the underpaint.

Preparations for Airbrushing. It is advisable, before using the airbrush, to remove the handle and see that the needle is seated properly and tightened securely in place. Turn the needle locknut counterclockwise to loosen the needle. Gently remove the needle from the brush, as shown in figure 4-2. Notice that the point has a very fine taper. It is important to protect this point at all times and to handle it carefully, as the slightest injury to the tip of the needle will result in improper functioning of the brush. When replacing the needle, rest one of your fingers at the end of the needle locknut, as shown in figure 4-2, to steady your hand while inserting the needle.

After assembling the airbrush, attach the color cup to the brush by inserting it in the hole on the right side of the brush just forward of the control lever. Do not force the cup in too hard, or the hole will be enlarged. The cup is held in place by friction. The cup should be adjusted so that it is in a vertical position when the brush is held at an angle of at least 45° to the illustration surface.

The pressure used to operate the airbrush is supplied by an air compressor, carbon-dioxide tank, or compressed-air tank. In any case, a regulator is used to maintain the correct pressure to the airbrush. A typical setup is shown in figure 4-3. This particular regulator has two gauges—one indicates the pressure in the tank and the other indicates the amount of pressure applied to the airbrush.

To adjust the regulator to the proper pressure for airbrushing, first close the air outlet leading to the airbrush tubing and turn the regulator handle counterclockwise until all pressure is relieved. Then open the valve on the tank. The pressure in the tank should register on the gauge on the right. If the regulating handle has been backed out all the way, there should be no pressure indicated on the airbrush pressure gauge dial. In the event that some pressure is recorded, wait until the pointer stops moving before turning the regulator

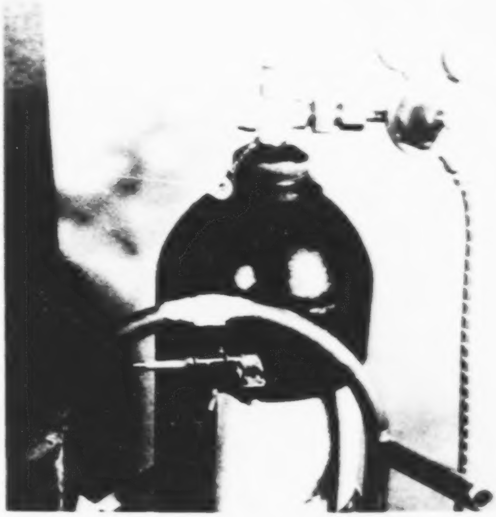


Figure 4-3. Air regulator.

handle. When the pointer comes to rest, the pressure can be increased by turning the regulator handle clockwise very slowly. Raise the pressure until the dial reads 25 pounds. The regulator is now set and will require no further attention. To turn off the air, you only need to cut it off at the tank valve.

Now you can attach the airhose to the regulator and to the airbrush. However, before attaching the hose to the brush, allow some air to pass through the hose to blow out any foreign matter that might be in the hose. Then screw the airbrush gently into the hose coupling, being careful not to strip any threads. As a general rule, handtightening is sufficient, but if air should leak out at the hose connection, tighten the swivel nut with the small wrench that comes with the airbrush.

Mix the desired pigment (lampblack or opaque color) to the desired consistency. Then transfer the solution to the cup by means of a bristle brush or an eye dropper.

Figure 4-4 shows the sequence you should use to obtain the proper grip on the airbrush. When you grasp lthe brush in this manner, the hose will be restrained by your wrist and will not flop annoyingly over the paper or in front of your work. You are now ready to airbrush.

Operating the Airbrush. Air and paint that pass through the airbrush are controlled by manipulation of the control level. The operation is shown in figure 4-5. When the control lever is in the raised position, as shown in the illustration to the left, neither air nor paint passes through the brush. When the control lever is pushed down, as shown in the center illustration, air passes through the brush but no paint is discharged. Pulling the control lever rearward releases the paint which is picked up by the airstream and sprayed from the nozzle. The amount of paint issuing from the brush is governed by the extent to which the trigger is pulled back.

As shown in figure 4-6, for airbrush painting flat tones, the airbrush should be held about 8 inches (203.20mm) away from the paper. In applying a flat wash, you use an arm movement, moving the brush back and forth across the paper at a slow, deliberate speed. The brush should be maintained at the same height and be point almost at right angles to the paper throughout the stroke. You should move your hand and forearm across the page without bending the wrist, the movement being from the shoulder.

On approaching the right edge of paper on the first stroke, press the control lever all the way down. This action releases only the air. Do this without stopping or slowing down the movement of your hand. All actions must be smooth and coordinated.

Now, while holding the control lever down, pull back on it slowly and evenly, releasing the point. The paint should dry almost as soon as it reaches the paper; if it puddles or fans out in streamlets, you are pulling back too far on the control lever or you are working too close to the paper.

After reaching the left edge of the paper, allow the control lever to move forward to its starting position so that the paint flow is gradually cut off. Then stop the motion of your arm.

Now start the next stroke in the opposite direction, following exactly the same procedure as before. Allow

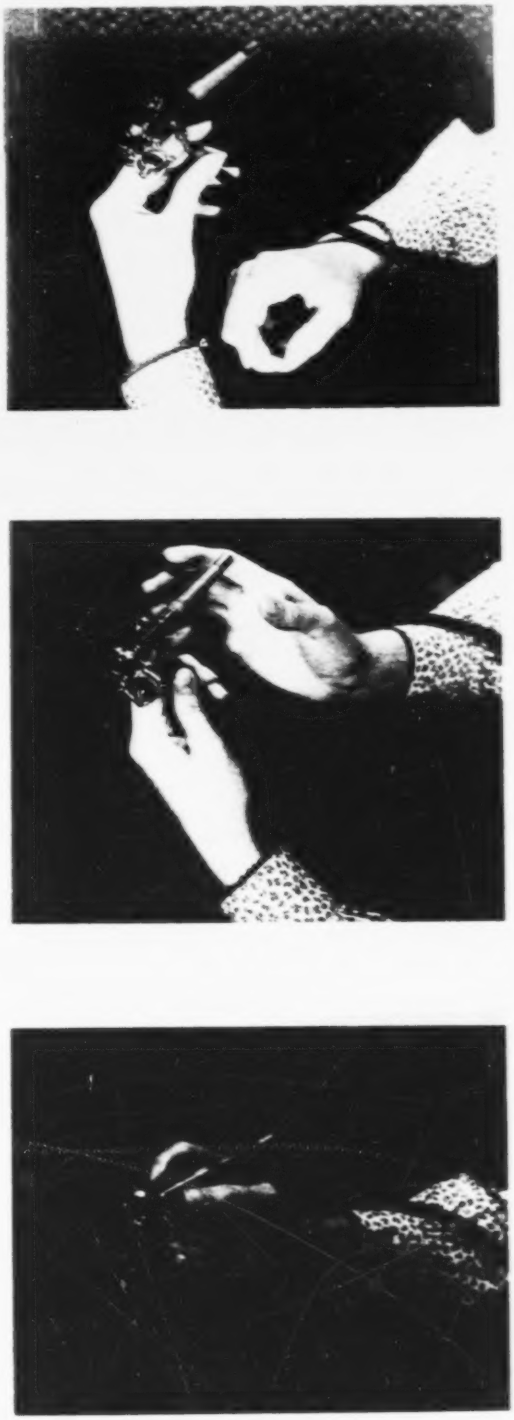


Figure 4-4. Procedures for obtaining the proper grip on an airbrush.

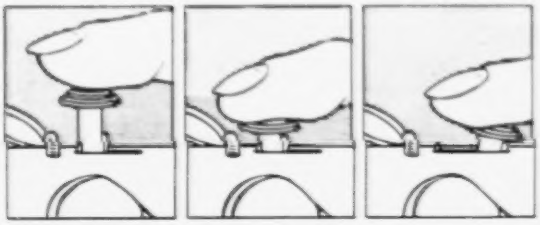


Figure 4-5. Controlling an airbrush.

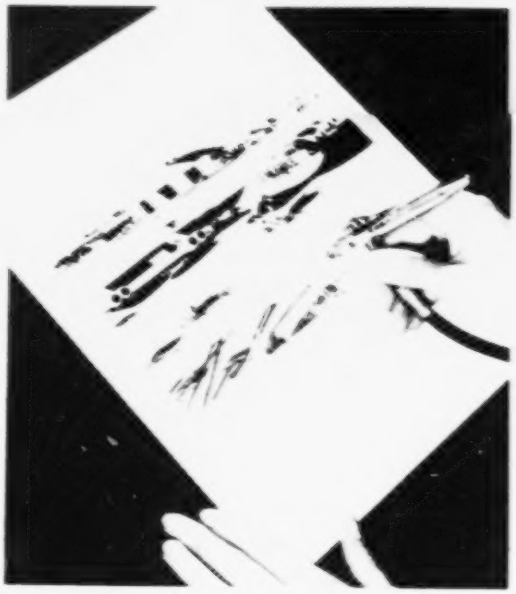


Figure 4-6. Proper airbrush position.

the spray to overlap the previous one along its edge. Continue these alternate strokes down the paper until the area is covered with a flat, even tone of color.

In airbrush painting, using transparent pigment, tones are built up gradually. If you desire a darker wash, go over the area again, starting at the top and repeating the procedure until the desired tone is obtained. A graded wash is best secured by starting at the bottom of the area with a light flat wash and allowing it to fade out near the top on the first passage. Then, start at the bottom again but do not take the spray up quite as far as on the previous passage, repeating this procedure until the required gradation is built up.

Figure 4-7 shows some of the common effects of improper airbrushing. The causes of the effects are listed below:

Grain. If the pattern becomes very grainy, it is generally because the pigment has not been diluted sufficiently with water. Grain may also be caused by an accumulation of paint on the airbrush tip, too low air pressure, or a bent needle.

Paper buckling. If the paper blisters or buckles, the paint is too thin, or too much paint is being applied to the paper during each stroke.

Blobs. If large spots of paint occur at the beginning of each stroke, you are releasing the paint before the hand is in motion. If the blob is at the end of the stroke, you are not allowing the control lever to move forward at the end of the stroke, shutting off the paint supply.

Flared strokes. This is caused by not moving the whole forearm across the paper when making strokes. You are merely turning the wrist in order to reach the edges of the paper.

Centipede effect. This is caused by airbrush painting too close to the paper and by pulling back too far on the control lever.

Splatter. Fairly large specks of color at the beginning of a stroke are generally caused by having allowed the control lever to "click" forward too abruptly at the end of the previous stroke. These specks may also be caused by clogging.

Curved strokes. Curved strokes are caused by dipping the hand down toward the paper. The hand should be kept at a uniform distance from the paper during a stroke, except where a line of varying width is desired.

Using a Frisket. When an area of an illustration is not to be painted, it is usually protected by means of a frisket or mask. The procedure for using a frisket is given and illustrated in figure 4-8, pages 1 and 2. The use of a mask is shown in figure 4-9. Masks may be cut out of paper or may be constructed out of masking tape, as the one shown in figure 4-9.

Basic Rendering Technique. To show the basic steps used in rendering an illustration by airbrush, using transparent wash, let's go over the steps used in rendering the sphere, shown in figure 4-10, as if you were airbrushing it:

1. First, draw a circle with a compass and place a frisket over it.
2. Cut out the circle. This can be done either freehand with a frisket knife, following the circle very carefully, or by using a blade in a compass.
3. Remove the frisket from the sphere and clean off the excess rubber cement.
4. Airbrush paint a very faint tone all around the edge of the sphere, allowing some of the tone to fall on the frisket. This should be done in short strokes, working in both directions. Long strokes would be more difficult to control. Keep the tone as even as possible, fading out gradually on the inside edge.
5. Carry this tone up further from the bottom, leaving the highlight—a small circular area at the upper left of the sphere—as white as possible.
6. Starting in the lower right area of the sphere a short distance in from the edge of the frisket, airbrush paint a shadow along the right side, across the bottom, and up the left side.
7. Leaving a reflected light, begin the heavy shading. This shading should also be done with short strokes in all directions. When fading out at the upper right and upper left, however, work only in one direction.

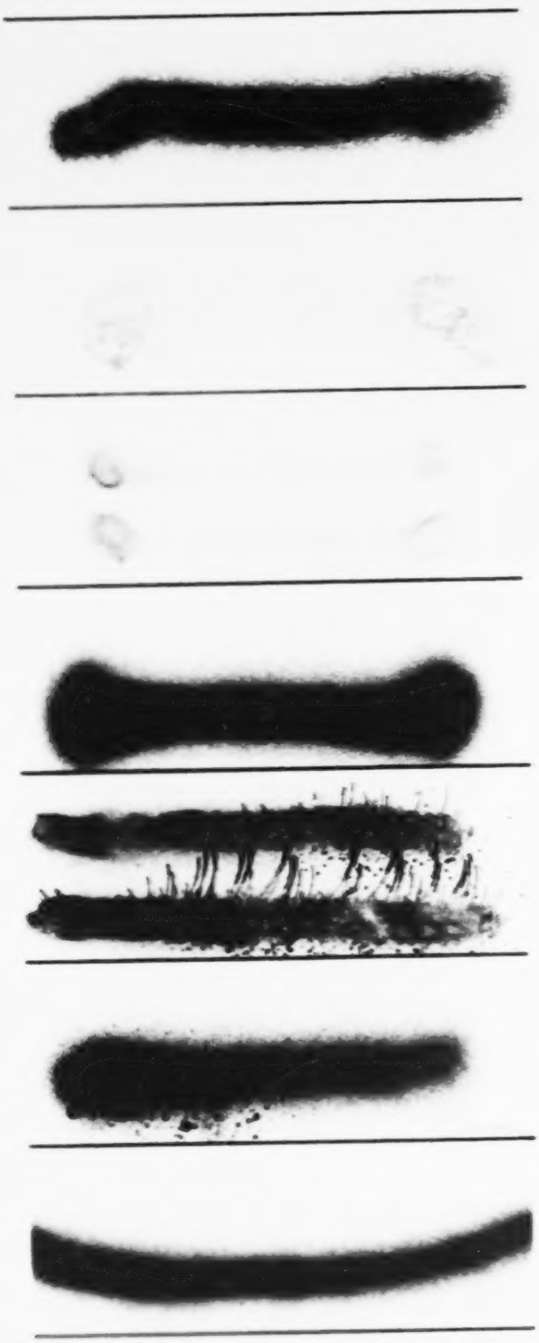


Figure 4-7. Identifying airbrush painting problems.

8. Airbrush paint a slightly darker tone off the edge of the frisket at the top of the sphere. Then, return to the lower right shadow area and continue to darken it, working in solid black tone.

Using opaque color to paint the same sphere is a much easier method, since you do not have to build up the tones gradually as you do with transparent wash. You merely lay down the middle tone and then add the highlights, shadows, and reflected light.

Exercises (417):

1. Why is the airbrush an excellent tool for illustrating?

2. How should you produce a sharp, straight edge of tone with an airbrush?

3. What is used to vary the sharpness and density of an airbrush stroke?

4. What is the principal difference between the techniques of airbrushing with transparent pigment and opaque pigment?

5. What preparations must be made before using an airbrush?

6. At what pressure should the airbrush be operated?

7. How is the airbrush controlled?

8. What factors of operator control determine the quality of an airbrush stroke?

9. What are the common effects that indicate an improper airbrushing technique?

4-2. Silk Screen Printing

There are many useful printing processes that incorporate certain features of letterpress, intaglio, and lithography, yet differ from these three basic processes.

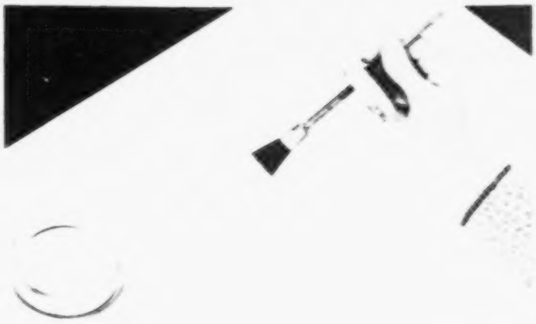


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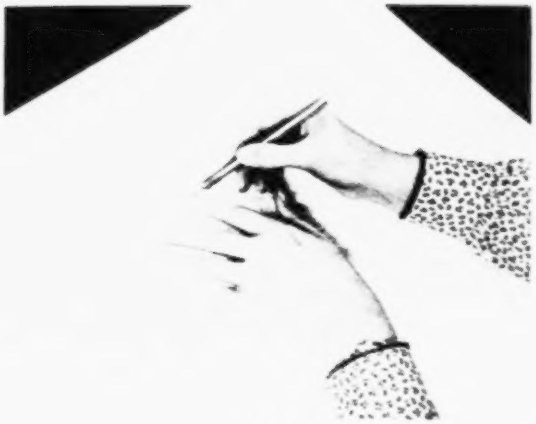
Figure 4-8. Procedure for using a frisket (page 1).



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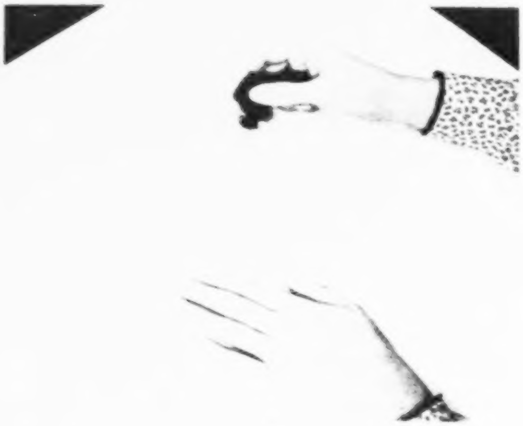

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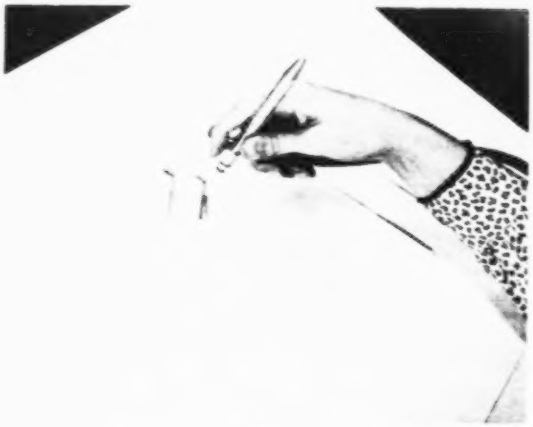

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Figure 4-8. Procedure for using a frisket (page 2).

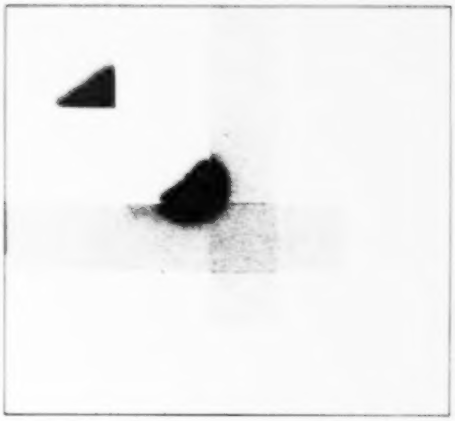

Figure 4-9. Using a mask while airbrushing.

Figure 4-10. Rendering a sphere.

One of these you are likely to use in your job as an illustrator is the silk screen process. This process can be used for printing on surfaces that are difficult to print on by any other method. Printing can be applied to fabrics, posters, glass, china, wood, cork, felt, metals, and cellophane, as well as many other materials.

The silk screen process is a stencil process. Three types of stencils are used—hand-cut stencils made from special film or lacquered paper, stencils prepared with brush and shellac called tusche, and stencils prepared by the photographic process on a sensitized silk screen.

418. Relate terms and procedures related to silk screening with their descriptions.

Materials. The materials needed to reproduce a design by the silk screen process are listed below:

a. Medium-mesh silk (48 meshes per lineal inch).
b. Adhering liquid.
c. Stencil material (Profilm, Nu-film).
d. Stencil knife.
e. Screen process paint.
f. Reducing varnish.
g. Squeege.
h. Paper masking tape.
i. Wooden frame.
j. Liquid tusche.
k. Lithograph pencils.
l. Removing liquid.

Printing Procedure. The first step in printing by the silk screen method is to construct the frame if one is not already available to hold the screen. The frame should be built of lightweight, well-seasoned lumber, with strong joints at the corners. The frame should be fastened to a table or board with hinges, as shown in figure 4-11. The silk should be so laid that the threads are parallel to the sides of the frame. The silk is held in place by a strip of twisted fibrous material which presses the silk tightly into a groove in the frame. It can also be stretched and tacked to the frame in a manner similar to stretching watercolor paper.

Master copy. The master copy is made by composing a layout of the design or illustration on drawing paper or bristol board the same size as the desired prints.

Cutting the film. The film is a thin transparent material attached to a layer of translucent paper. A piece of film just large enough to cover the actual drawing is fastened over the master copy with the film side up. Thumbtacks or adhesive tape are used to fasten the film to the board over the master copy. A sharp stencil knife is used to cut the design in the film, cutting through only the film and not the backing paper. As an area is outlined with the knife, the film covering the design to be printed is lifted carefully and stripped from the backing paper.

Attaching the stencil to the screen. The stencil, backing paper and all, is placed film side up under the screen in a position that will permit the correct application of the ink on the material to be printed. Newspaper or other scrap paper is placed under the film to force it into contact with the silk. A small soft cloth saturated with adhering liquid is rubbed quickly over a small area of the silk covering the film. A large soft cloth is wiped over this portion at once to absorb any excess liquid since too much liquid will spoil the film. A darkening of the film usually indicates that the film has adhered.

When the entire surface has been attached, allow it to dry for about 15 minutes, then raise a corner of the paper backing to detach the backing from the film. If the film is raised from the silk at any point, it must be replaced, the screen turned over, and adhering liquid used until it is firmly fastened.

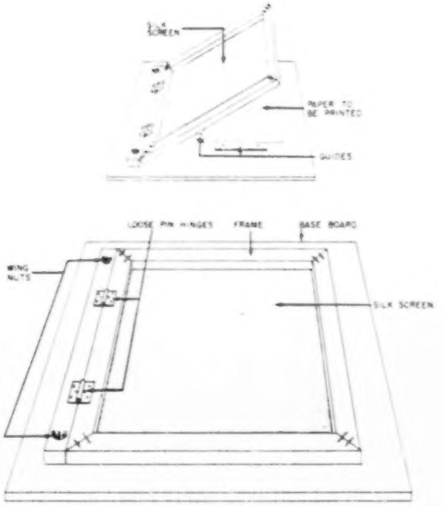

Figure 4-11. Silk screen.

The open spaces around the stencil are blocked out with adhesive paper or masking tape to prevent any unnecessary parts from printing. Tape is also applied on the inside of the screen around the edges of the silk to prevent ink from working under the frame. The squeegee, which is a blade of rubber about 1/4-inch thick and which fits lengthwise into a slot of wooden handle, should be nearly as wide as the inside of the frame. The squeegee is placed at the top of the frame.

Printing. A special paint is used. It is mixed to the consistency of thick cream. The paper or cloth to be printed is fed against register guides (see the top illustration of fig. 4-11) on the board under the silk, and the screen is lowered over it. The paint is then poured upon the screen at one end and pulled across the screen with an even pressure stroke of the squeegee. This action forces the paint through the open portion of the stencil. This operation is repeated in the opposite direction for the next print. The entire procedure is repeated until the required number of copies are printed.

Cleaning the silk. The film or paper stencil should be removed from the screen after the run has been completed. This is done by brushing a small amount of the film remover on the silk. After it stands for a few minutes, the paper stencil may be peeled off. If film is used, it must be rubbed with cloth and removing liquid. The silk should be finally cleaned with the same liquid, by scrubbing it between two wads of cloth dampened with the removing liquid.

Methods of Producing Stencils. Besides the film method, there are several other ways of producing stencils. Some of the important other types of stencils are shellac, lacquer, tusche, and direct photography.

Shellac stencils. The paper cut stencil is a simple and easy way to prepare the image for the silk. A sheet of thin tracing paper is first coated with two coats of orange shellac. The original drawing, made on drawing paper or bristol stock, is then covered with rubber cement. The shellac-coated paper is placed over the original drawing, shellac side up. When it is smoothed out, the cement will hold the tracing paper in place. The design is then cut through the tracing paper, and the parts that are to show up in the print are removed, while the centers remain in place. The screen is placed over the shellac-coated paper, and the paper is adhered to the silk by moving a warm iron over the silk on the inside of the screen. The iron should be just warm enough to heat the shellac and cause the stencil to adhere to the silk. A cloth with a few drops of alcohol on it may also be used to dissolve the shellac and make it adhere to the silk. The original drawing is stripped off after the stencil has been attached to the screen; then the rubber cement is removed by rubbing. The mesh of the silk must be cleaned with benzine or naphtha in order that a clear print will result. The screen is then ready for mounting and printing.

Lacquer stencils. A stencil similar to the shellac stencil can be made with lacquer. The paper is first coated with lacquer, the design cut out and placed lacquer side up against the silk. It is attached by wiping over the silk with a cloth moistened with lacquer thinner, softening the lacquer and causing the stencil to adhere to the silk. The silk should be wiped with a dry cloth after it has been wiped with the thinner to take up the excess thinner and allow the lacquer to stick.

Glue may also be used as an adhesive to mount the stencil onto the silk. It is applied in the same manner as the lacquer or shellac, using a damp cloth and a warm iron.

Tusche method. Lettering and drawing may be applied to the screen by the use of liquid tusche. The silk screen is placed over the preliminary drawing, and the tusche is painted on the silk over the elements of the drawing.

Although the tusche can be thinned out with distilled water, it is insoluble after it dries. Fish glue, thinned with water, is brushed over the entire screen on the inside, allowed to dry, and brushed on a second time. When this dries, the tusche is washed out by rubbing both sides of the silk with soft cloths soaked in turpentine. The dissolving tusche carries away the glue over it, leaving the clean screen open at all points where the tusche is applied.

Masking paper is attached to the underside of the screen over all areas not opened, and scotch tape is fastened around the frame on the inside.

Direct photographic method. Another method of preparing the screen is by photography. Designs that are too intricate to produce on paper or film stencils are done by this method. Pictorial designs, pen and ink sketches, halftones, and other types of complicated subjects can be produced on the sensitized screen.

The screen for the direct photographic method is coated with a bichromated solution of glue or gelatin. The coating is allowed to dry and the plate is placed with the film or ink side against the sensitized silk. It is locked in a contact frame and exposed to a strong light. The amount of exposure depends on the solution used and the intensity of the light. The screen is etched out in warm water after it has been removed from the contact frame. It must be kept under subdued light until it has been dampened on both sides. Enlarged or reduced prints may also be made.

Exercise (418):

1. Match the characterizing statements in column B with the item listed in column A.

Column A

___ (1) Direct photographic method.
___ (2) Film.
___ (3) Medium mesh.

Column B

a. 48 per lineal inch.
b. Made by making layout of design on drawing paper or bristol board.

Column A

___ (4) Printing.
___ (5) Lacquered stencil.
___ (6) Cleaning silk.
___ (7) Master copy.
___ (8) Attaching stencil to screen.
___ (9) Shellac stencil.
___ (10) Tusche method.

Column B

c. Attached to layer of translucent paper, thumbtacks or adhesive tape.
d. Cloth saturated with adhering liquid is rubbed over small area.
e. Special solution is used and poured upon screen at one end.
f. Uses film remover.
g. Original drawing covered with rubber cement.
h. Attach by wiping over the silk with a cloth moistened with thinner, or glue.
i. 56 per lineal inch.
j. Can be thinned with distilled water.
k. Used for intricate designs, pictorial designs, pen and ink sketches and halftones.

Bibliography

ECI Course

CDC 23131, Volume 1, *Fundamentals of Graphics*. Extension Course Institute, Gunter Air Force Station, Alabama 36118.

Books

Birren, Faber, Principles of Color: *A Review of Past Traditional and Modern Theories*. New York, New York: Lilton Educational Publishing Company, 1969.

M. Grumbacher, Inc., *1977 Grumbacher Catalogue*. M Grumbacher, Inc., 460 West 34th St., New York, New York 10001.

Richmond, Leonard and Littlejohns, J., *Fundamentals of Watercolor*, and *Fundamentals of Pastels*, 12th ed. New York, New York: The Watson Guptill Publishing Company.

Spencer, Henry C., *Basic Technical Drawing*, 7th ed. New York, New York: The MacMillan Publishing Company, 1968.

Department of the Navy Publication

NAVTRA 10469-A, *Illustrator Draftsman 3 & 2*.

Answers for Exercises

CHAPTER 1

Reference:

400 – 1. 1. i.
2. b.
3. h.
4. a.
5. d.
6. f.
7. e.
8. g.
9. c.

401 – 1. General-purpose.
401 – 2. Special-purpose table.
401 – 3. Columns, rows, boxhead, captions, stub, and stub items.
401 – 4. Accurate, timely, and clearly.
401 – 5. Range of values.
401 – 6. They help you to plot the data, and they enable the reader to assign a value to each plotted point.
401 – 7. To keep from misleading the reader. To keep from creating a false impression when the data is expressed on a bar chart.

402 – 1. Bar chart.
402 – 2. Pie chart.
402 – 3. Line chart.
402 – 4. To show progressive steps of an operation.
402 – 5. Organizational chart.
402 – 6. The movement of data through time and the magnitude of the data.
402 – 7. Interestingly prepared charts attract and hold attention.
402 – 8. Determine what percent of the whole each component represents.
402 – 9. Divide the part by the whole.
402 – 10. Multiple the percentage by 3.6.

CHAPTER 2

403 – 1. The wet process uses a developer solution that contains the coupler. The solution activates the dyes and produces the image. The dry process uses ammonia vapors that activate the coupler which coats the film.
403 – 2. Second originals are more durable than the paper originals. Many more copies can be produced from second originals.

404 – 1. Diazo transparencies are larger than most slides, thus (in terms of drawing) more detailed. It is easier to cut out mistakes from a diazo transparency.
404 – 2. Refer to a chart, such as the one shown in figure 2-3.
404 – 3. Registration.

405 – 1. Ordinary paper.
405 – 2. By heat.
405 – 3. It prepares paper offset masters.

405a – 1. You can produce a transparency using practically any printed materials.
405a – 2. The four steps in the operation of a Thermofax copier are:
(1) Adjust the exposure.
(2) Place film on the original.
(3) Center material and insert it into the machine.
(4) Mount the transparency.
405a – 3. Thermofax films should be placed over the original with the notched corner over the upper righthand side.

406 – 1. The size of the slide.
406 – 2. The time necessary for actual production.
406 – 3. To allow for variances in camera alignment and mounting.
406 – 4. Before the job is sent to the photolab.
406 – 5. The photolab. To find out what type of film they use before you begin work on the job request.
406 – 6. On a piece of tracing paper that is laid over artwork.

407 – 1. 6 by 8 2/3 inches.
407 – 2. 6 by 12 inches.

408 – 1. The lettering must be 1/15 of the height of the graphic. In this case it must be 2/3 (10:15 – 2/3). The line weight must be at least 1/75 of 13 1/3 inches. Therefore, it must be at least 1/6 inch thick.
408 – 2. Since the minimum height for lettering is 1/15 of the graphic height, the largest that the graphic can be is 15 times the height of the lettering which is 5 inches (15 × 1/3 = 5).
408 – 3. If the graphic can be seen on the monitor with sufficient clarity to illustrate its point, your sizes and styles are appropriate.

409 – 1. The advantage of using black and white in all TV illustrations is that is gives the video engineer a reference on which to set up basic video levels. Besides the fact that black and white may not fit well into the design of an illustration, using black and white next to each other may cause a halo or horizontal streaking.
409 – 2. The TV system is not as effective in distinguishing tone as is the human eye. If you did not restrict your use of gray to 3 or 4 separated tones, some of the different tones might appear to be the same tone.
409 – 3. You should compare the value of colors with the values of gray.
409 – 4. Lay a sheet of wax paper over your illustration and step back to the appropriate viewing distance. The net result is very similar to what the TV system does to your illustration. BIG, BOLD, and SIMPLE is the criterion to apply.

410 – 1. 1. f.
2. e.
3. a.
4. g.
5. h.
6. b.
7. d.
8. c.

CHAPTER 3

411 – 1. (1) c; (2) a; (3) d; (4) b.

412 – 1. A galley copy is a proof page used to check for printing errors and quality. A slick copy is the final layout copy.
412 – 2. To work out general ideas and copy-layout problems.
412 – 3. Allows you to fit the copy evenly into the column areas.
412 – 4. Ruby-lith, parapaque, or by blackening the areas with ink or black paper.
412 – 5. Cutting out all the unnecessary areas of a picture to improve its content; the two methods most commonly used are the tissue-overlay method and the outline method.

412 - 6. Label the photos with the page number and window position.
412 - 7. A proportional scale is the best tool

413 - 1. Printing presses can print in black and white only.
413 - 2. A screen breaks a photograph up into a series of dots that vary in size and spacing. When printed in black and white, the eye sees a variation of tone.
413 - 3. A device made of two pieces of optical glass that have parallel, opaque lines running across them.
413 - 4. The number of lines per inch.

414 - 1. Retouching adds the qualities to a photograph that the photographer failed or could not obtain.
414 - 2. The phantom effect is obtained by laying a sheet of Solotone over the photograph and scraping away the surface over the subject.

415 - 1. The mixture of the three primaries does not produce a neutral black. It is also used to give tone and body to other colors.
415 - 2. 1. a, h.
    2. k, g, l.
    3. c.
    4. j.
    5. m.
    6. f.
    7. n.
    8. n.
    9. o.
    10. p, d.
    11. b.
    12. i, e.

416 - 1. It serves as a flat surface upon which the copy is attached to be photographed.
416 - 2. Arc lamps, quartz iodine lamps, or pulsed xenon lamps.
416 - 3. The lens, the aperture, and the shutter. The lens focuses the light, the aperture controls the amount of light that strikes the film, and the shutter control the length of time the light strikes the film.
416 - 4. Glass focal plane.
416 - 5. It holds the shutter open and the lights on until a complete exposure has been made.

416a - 1. It increases the light output of the projector by 10 percent.
416a - 2. Wipe off your fingerprints.
416a - 3. The outside lenses of the projection heads and the top surface of the optical stage.
416a - 4. Use only a camel's hair brush
416a - 5. Insert the material to be projected in the space between the projector body and the feedomatic belt, with the bottom of the copy towards the screen.
416a - 6. A glass pressure plate keeps photos and books flat for projection.
416a - 7. The heat filter is used to provide protection to temperature-sensitive materials or thick materials that are to be left in the projector for any periods of time.
416a - 8. The front projector mirror.
416a - 9. The drawing must first be traced on translucent paper and then retraced on another drawing surface.
416a - 10. A place where the lighting can be controlled.

CHAPTER 4

417 - 1. Because it is capable of producing even tones, gradual variations in value, and sharp tonal contrast.
417 - 2. Cover part of the paper with a mask or frisket.
417 - 3. Raised mask.
417 - 4. With transparent pigments, the amount of paint applied determines the value. With opaque pigment, the addition of white for lighter values, and black for darker values.
417 - 5. Before airbrushing, you should check the needle for proper seating and security, attach the color cup, attach the hose, check the air pressure, mix paint, and fill the cup.
417 - 6. 25 pounds.
417 - 7. The airbrush has a control level; pushing down releases the air and pulling back releases the paint.
417 - 8. (a) The distance between brush and paper.
    (b) The position of brush in relation to paper.
    (c) The amount of paint released by the control level.
417 - 9. Grain, paper buckling, blobs, flared strokes, centipede effect, spatter, and curved strokes.

418 - 1. 1. k.
    2. c.
    3. a.
    4. e.
    5. h.
    6. f.
    7. b.
    8. d.
    9. g.
    10. j.

STOP - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

23151 03 23

VISUAL COMMUNICATIONS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover *your* answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor. If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual VRE items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the *best* answer to each question.

1. (400) A narrative presentation may be either written or oral, and is normally presented in

   a. slide form.
   b. story form.
   c. data form.
   d. graphic form.

2. (400) The two advantages of an oral presentation are

   a. personal presentation and answering questions.
   b. visual response and evaluation of presentation.
   c. large amounts of material presented and question response.
   d. correction ability and clarification response.

3. (401) What is the first element to be considered when drawing a tabular presentation?

   a. The color.
   b. The size.
   c. The title.
   d. The body of the presentation.

4. (401) In the body of a table, the boxhead

   a. is the term used for vertical listings.
   b. is the term used for stubs.
   c. contains the titles appearing in the stub.
   d. contains the captions of the vertical columns.

5. (401) The lower left-hand corner of a chart is used to indicate the

   a. scale or range of values.
   b. legend applicable to the chart.
   c. preparation information.
   d. source of the data.

6. (402) When the bars extend upward or grow from the base line at the bottom of the chart, this chart is called a

   a. vertical bar chart.
   b. vertical line chart.
   c. horizontal bar chart.
   d. horizontal line chart.

7. (402) On a bar chart, the spacing between the bars is equal to the

   a. width of a bar.
   b. height of a bar.
   c. length of a bar.
   d. thickness of a bar.

8. (403) When producing diazotype images, the ammonia developing process is a

   a. wet process.
   b. dry process.
   c. semimoist process.
   d. semidry process.

9. (403) If you are allergic to ammonia, the type of diazo process you should avoid using is the

   a. moist process.
   b. semidry process.
   c. dry process.
   d. ultraviolet process.

10. (403) The term diazo refers to what organic chemicals?

a. Diazonium salts and acetone.
b. Acetate and color couplers.
c. Acetone and color couplers.
d. Diazonium salts and color couplers.

11. (404) Which of the following is used to correct mistakes on a tracing paper master for a diazo print?

a. Erasure.
b. Cut out.
c. Overlay.
d. Block out.

12. (405) The xerox process is based on the principle of

a. repellency of water and oil.
b. dry electrostatic transfer.
c. lithographic printing.
d. diazotype printing.

13. (405) One advantage of the dry electrostatic process is

a. that it uses ordinary paper.
b. that liquid chemicals are at a minimum.
c. that it produces a high quality reproduction.
d. that it is inexpensive and highly reliable.

14. (405) During the xerox printing process, the paper offset master or transparency receives

a. a negative charge.
b. a chemical coating.
c. exposure through a camera lens.
d. a positive charge.

15. (405a) Besides transparencies, which of the following products can be printed using the Thermofax?

a. Gummed labels and Technisheen.
b. Gummed labels and paper copies.
c. Paper copies and prepared lettering.
d. Technisheen and prepared lettering.

16. (405a) What is the major drawback of the Thermofax process?

a. Quality of the slide.
b. Time of production.
c. Complexity of operation.
d. Maintenance of machine.

17. (406) What is the greatest disadvantage of 35mm slide production?

a. Processing cost.
b. Processing time.
c. Size limitations.
d. Correction limitations.

18. (406) A limiting factor when working with 35mm transparencies is that you must always

a. work with the existing color sensitive film.
b. work without bleed area interference.
c. work within a two by three format.
d. work within the drop shade factor.

19. (407) Concerning visual materials for television, aspect ratio refers to the

a. width of the TV screen.
b. relationship of height to number of lines.
c. relationship of width to number of lines.
d. relationship of height to width of TV screen.

20. (407) The rule that allows for edge loss and establishes a safety field is called the

a. one-eighth rule.
b. one-sixth rule.
c. one-fourth rule.
d. one-half rule.

21. (408) The minimum line weight for a television graphic is

a. 1/75 the width of the copy layout.
b. 1/50 the width of the copy layout.
c. 1/25 the width of the copy layout.
d. 1/15 the width of the copy layout.

22. (408) You have to make nine graphic television illustrations having a basic size of 10 by 13 1/3 inches. How many sheets of 30 by 40 inch television gray board will be required?

a. Four.
b. Three.
c. Two.
d. One.

23. (409) For television, using black and white next to each other may cause

a. a fade out.
b. a grayed blending.
c. an all black presentation.
d. a halo and horizontal streaking.

24. (409) To allow the television engineer to set video levels, what must be included in each television graphic?

a. Both black and white.
b. Either black or white.
c. Three or four tones of gray.
d. Black, white, and a medium gray.

25. (409) On black and white television when you place two slightly different gray tones side by side, the

a. background is grayed.
b. objects will probably look alike when reproduced on screen.
c. color difference will be exaggerated by the camera.
d. objects will appear more clearly on the screen.

26. (409) The resolution of a television system tells the illustrator how

a. to apply ink by hand.
b. to use registration marks.
c. a mistake can be corrected.
d. much fine detail he can put into an illustration.

27. (410) The original artwork for rear view projection is photographed and normally reduced to a

a. 3- by 4-inch transparency.
b. 5- by 7-inch transparency.
c. 2- by 2 or 4- by 5-inch transparency.
d. 8- by 10-inch transparency.

28. (410) The principle of the phantom is based on

a. color values.
b. line construction.
c. drawing an illustration on a gray background using charcoal sticks.
d. drawing an illustration on a white background using a number B1 pencil.

29. (410) The simplest method of presenting animation on television is by using

a. technamation.
b. the crawl technique.
c. slide cards.
d. pop-in.

30. (410) Information appearing in a cutout window or picture frame type setting is an example of a

a. gobo.
b. crawl.
c. pop-in.
d. slide card.

31. (411) What type of printing has the letters or designs etched below the printing surface?

a. Offset.
b. Lithographic.
c. Intaglio.
d. Letterpress.

32. (411) What is the definition of planography?

a. The process of using lithographic stone in the printing process.
b. The process of lithographic printing when metal plates are used.
c. The act of etching letters and designs in the printing surface.
d. The process of making letters and designs on blocks of wood.

33. (412) A galley copy is used to

a. check for mistakes after type has been set.
b. paste up the final layout.
c. show column layout borders.
d. record windows for layout photographs.

34. (412) Cropping can be accomplished in two ways, one of these ways is to use

a. an acetate overlay.
b. a black ink overlay.
c. a ruby-lith parapaque overlay.
d. a tissue-overlay.

35. (413) The halftone process is very similar to what line media technique?

a. Graded line.
b. Crosshatch.
c. Stipple line.
d. Accentuated line.

36. (413) The screen used in the halftone process is made up of two pieces of optical glass that have

a. parallel, opaque lines running across them.
b. screening material attached to them.
c. black dots embedded in the surface of the glass.
d. polished reflecting surfaces.

37. (414) The purpose of photo retouching is to

a. bring the photograph into proper proportion.
b. accentuate minor background details.
c. eliminate distraction qualities.
d. highlight the depth of field.

38. (414) What is the simplest technique for subduing the background of a photograph?

a. Apply a light transparent wash over the background.
b. Use an airbrush and opaque paint to retouch the area.
c. Stipple the area using a large bristle brush and retouch grays.
d. Use a Solotone sheet over the photograph and scrape away the surface over the subject.

39. (415) How is color achieved in halftone color separation negatives made directly from the original color illustration?

a. By photographing the original artwork in full color.
b. By using a subtractive color separation process and monochrome filters.
c. By making screen negatives directly from the artwork by using filters.
d. By using an additive color separation process and complimentary filters.

40. (415) In the photoengraving processes, a red printer uses

a. a yellow-red filter.
b. a green (yellow-blue) filter.
c. an orange filter.
d. a blue-violet filter.

41. (415) What simple method can an illustrator use to indicate to the lithographer the desired color separation of a finished product?

a. Key line method.
b. Tissue overlay method.
c. Acetate overlay method.
d. Color strip method.

42. (416) The shutter of the copy camera system is held open by the

a. aperture setting.
b. light source setting.
c. timer setting.
d. exposure setting.

43. (416) With the acetate overlay method

a. color work with large masses may be treated.
b. the sheet is placed on the original drawing, frosted side down.
c. the areas containing color are outlined and filled in with pencil.
d. the sheet is placed on the original drawing, frosted side up.

44. (416) What part of the copy camera system holds the copy to be photographed?

a. The copyboard.
b. The glass focal plane.
c. The aperture frame.
d. The film holder.

45. (416a) Which of the following control features eliminates the red and blue corners that are projected onto the screen?

a. Lamp change lever.
b. Lamp indicator lever.
c. Opitcal intensifier.
d. Optical tuning wheel.

46. (416a) How is surface dirt removed from the mirrors of an overhead projector?

a. Damp rag. c. Dry paper towel.
b. Camel's hair brush. d. Dry rag.

47. (416a) What type of materials must be used to project an image when using a Lucida projector?

a. Opaque. c. Translucent.
b. Transparent. d. Frosted.

48. (417) When working in transparent wash, to render an area with strong highlights and shadows, you should

a. cover the highlights with white paint after painting all the dark tones.
b. cover the area with a frisket so that the area will not be painted.
c. airbrush the dark tones only, leaving the highlights.
d. cover the highlights with white paint before painting the dark tones.

49. On a double-action airbrush, the largest amount of paint will be sprayed when the lever is

a. all the way down and all the way to the rear.
b. all the way down and slightly to the rear.
c. all the way up and all the way to the rear.
d. slightly down and slightly to the rear.

50. (417) Fairly large specks of color at the beginning of an airbrush stroke are generally caused by

a. pulling back too slowly on the control lever.
b. allowing the control lever to click forward too quickly at the end of the previous stroke.
c. pulling back too quickly on the control lever.
d. releasing the control lever too slowly on the previous stroke.

51. (418) The process of printing which allows the greatest selection of printing surfaces is the

a. gravure. c. lithography.
b. letterpress. d. silk screen.

52. (418) What is an important precaution to observe when cutting a film stencil for the silk screen process?

a. Do not cut the silk.
b. Do not cut the backing paper.
c. Do not remove any of the film.
d. Do not apply too much lacquer thinner.

53. (418) When preparing the silk screen for printing, the film stencil is attached to the silk by applying

a. an adhering liquid. c. paper tape.
b. a warn iron. d. turpentine.

54. (418) What type of stencil can be attached to the silk by heating it with a warm iron?

a. Lacquer. c. Film.
b. Shellac. d. Tusche.

55. (418) In making a stencil for the silk screen during the tusche method, what is used to block out the areas of the design which are not printed?

a. Rubber cement.
b. Masking paper.
c. Fish glue.
d. Mucilage.

END OF EXERCISE

MAIL TO: ECI, GUNTER AFS AL 36118-5643

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012. PRINCIPAL PURPOSE: To provide student assistance as requested by individual students. ROUTINE USES: This form is shipped with ECI course package, and used by the student, as needed, to place an inquiry with ECI. DISCLOSURE: Voluntary. The information requested on this form is needed for expeditious handling of the student's inquiry. Failure to provide all information would result in slower action or inability to provide assistance to the student.

I. CORRECTED OR LATEST ENROLLMENT DATA

1. THIS REQUEST CONCERNS COURSE (1-6)	2. TODAY'S DATE	3. ENROLLMENT DATE	4. AUTOVON NUMBER
5. SOCIAL SECURITY NUMBER (7-15) – –	6. GRADE/RANK	7. NAME (First initial, second initial, last name) (17) – (18) – (19-32)	
8. ADDRESS OJT ENROLLEES: Address of unit training office with zip code. ALL OTHERS: Current mailing address with zip code.	(33-53) (54-75)		
9. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE	10. TEST CONTROL OFFICE ZIP CODE/SHRED (33-38)		

II. REQUEST FOR MATERIALS, RECORDS, OR SERVICE

X	Place an 'X' through number in box to left of service requested.
1	Request address change as indicated in Section I, Block 8.
2	Request Test Control Office change as indicated in Section I, Block 10.
3	Request name change/correction. *(Provide Old or incorrect data here)*
4	Request Grade/Rank change/correction.
5	Correct SSAN. *(List incorrect SSAN here.)* *(Correct SSAN should be shown in Section I.)*
6	Extend course completion date. *(Justify in "Remarks")*
7	Request enrollment cancellation. *(Justify in "Remarks")*
8	Send VRE answer sheets for Vol(s): 1 2 3 4 5 6 7 8 9 10 Originals were: [ ] Not received [ ] Lost [ ] Misused
9	Send course materials. *(Specify in "Remarks")* [ ] Not received [ ] Lost [ ] Damaged
10	Course exam not yet received. Final VRE submitted for grading on ____________ (date).
11	Results for VRE Vol(s) 1 2 3 4 5 6 7 8 9 10 not yet received. Answer sheet(s) submitted ________________ (date).
12	Results for CE not yet received. Answer sheet submitted to ECI on ____________ (date).
13	Previous inquiry ([ ] ECI Fm 17, [ ] ltr, [ ] msg) sent to ECI on ____________ (date).
14	Give instructional assistance as requested on reverse.
15	Other *(Explain fully in "Remarks")*

FOR ECI USE ONLY

16 G	33	
K	VOL 33-35	GR 36-38
M	33-34	35-40
N	33-35	
P	VOL 33-35	
	TC 36-37	38
	DOE 39-45	
Q	33-34 00	38 1
	MC 39-42	

REMARKS *(Continue on reverse)*

OJT STUDENTS must have their OJT Administrator certify this record.

ALL OTHER STUDENTS may certify their own requests.

I certify that the information on this form is accurate and that this request cannot be answered at this station.

SIGNATURE

ECI FORM DEC 84 17 PREVIOUS EDITION WILL BE USED.

REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of subject matter should be forwarded directly to preparing agency. For an immediate response to these questions, call or write the course author directly, using the AUTOVON number or address in the preface of each volume. All other inquiries concerning the course should be forwarded to ECI.

VRE ITEM QUESTIONED:

COURSE NO ____________

VOLUME NO ____________

VRE FORM NO ____________

VRE ITEM NO ____________

ANSWER YOU CHOSE ____________ *(Letter)*

HAS VRE ANSWER SHEET BEEN SUBMITTED FOR GRADING?

☐ YES ☐ NO

REFERENCE

(Textual reference for the answer I chose can be found as shown below.)

IN VOLUME NO ____________

ON PAGE NO ____________

IN ☐ LEFT ☐ RIGHT COLUMN

LINES ________ THROUGH ________

MY QUESTION IS:

REMARKS

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. Course workbooks have a Form 17 printed on the last page.

ECI FORM 17, DEC 84 *(Reverse)*